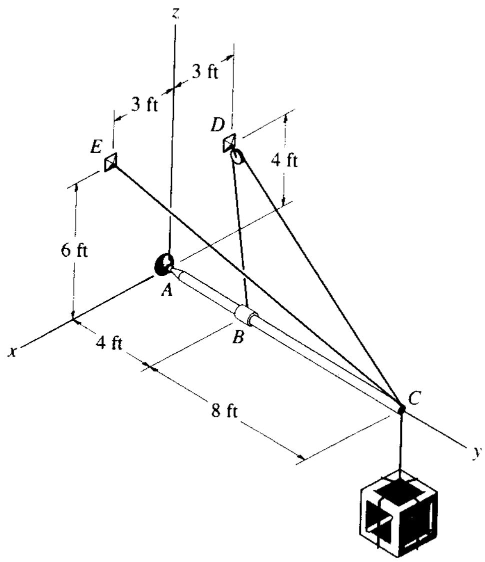
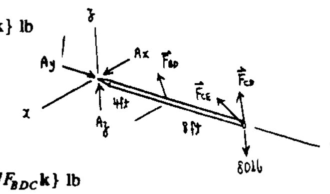
*5-84. The boom AC is supported at A by a ball-and-socket joint and by two cables BDC and CE. Cable BDC is continuous and passes over a pulley at D. Calculate the tension in the cables and the x, y, z components of reaction at A if a crate has a weight of 80 lb.



$$\mathbf{F}_{CE} = F_{CE}\frac{(3\mathbf{i} - 12\mathbf{j} + 6\mathbf{k})}{\sqrt{3^2 + (-12)^2 + 6^2}}$$

$$= \{0.2182F_{CE}\mathbf{i} - 0.8729F_{CE}\mathbf{j} + 0.4364F_{CE}\mathbf{k}\}\ \text{lb}$$



$$\mathbf{F}_{CD} = F_{BDC}\frac{(-3\mathbf{i} - 12\mathbf{j} + 4\mathbf{k})}{\sqrt{(-3)^2 + (-12)^2 + 4^2}}$$

$$= \{-0.2308F_{BDC}\mathbf{i} - 0.9231F_{BDC}\mathbf{j} + 0.3077F_{BDC}\mathbf{k}\}\ \text{lb}$$

$$\mathbf{F}_{BD} = F_{BDC}\frac{(-3\mathbf{i} - 4\mathbf{j} + 4\mathbf{k})}{\sqrt{(-3)^2 + (-4)^2 + 4^2}}$$

$$= F_{BDC}(-0.4685\mathbf{i} - 0.6247\mathbf{j} + 0.6247\mathbf{k})$$

$\Sigma M_x = 0;\quad F_{BDC}(0.6247)(4) + 0.4364F_{CE}(12) + 0.3077F_{BDC}(12) - 80(12) = 0$

$\Sigma M_z = 0;\quad 0.4685F_{BDC}(4) + 0.2308F_{BDC}(12) - 0.2182F_{CE}(12) = 0$

$F_{BDC} = 62.02 = 62.0$ lb **Ans**

$F_{CE} = 109.99 = 110$ lb **Ans**

$\Sigma F_x = 0;\quad A_x + 0.2182(109.99) - 0.2308(62.02) - 0.4685(62.02) = 0$

$A_x = 19.4$ lb **Ans**

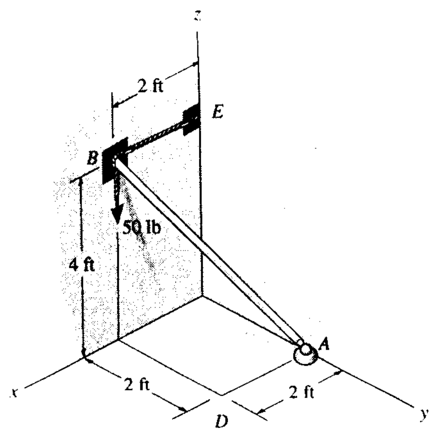
$\Sigma F_y = 0;\quad A_y - 0.8729(109.99) - 0.9231(62.02) - 0.6247(62.02) = 0$

$A_y = 192$ lb **Ans**

$\Sigma F_z = 0;\quad A_z + 0.4364(109.99) + 0.3077(62.02) + 0.6247(62.02) - 80 = 0$

$A_z = -25.8$ lb **Ans**

5-85. Rod AB is supported by a ball-and-socket joint at A and a cable at B. Determine the x, y, z components of reaction at these supports if the rod is subjected to a 50-lb vertical force as shown.



$\Sigma F_x = 0; \quad -T_B + A_x = 0$

$\Sigma F_y = 0; \quad A_y + B_y = 0$

$\Sigma F_z = 0; \quad -50 + A_z = 0$

$\Sigma M_{Ax} = 0; \quad 50(2) - B_y(4) = 0$

$\Sigma M_{Ay} = 0; \quad 50(2) - T_B(4) = 0$

$\Sigma M_{Az} = 0; \quad B_y(2) - T_B(2) = 0$

Solving,

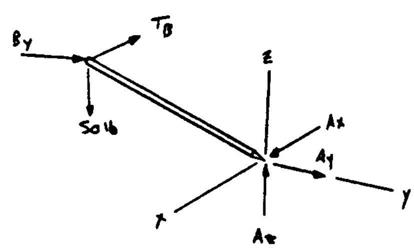
$T_B = 25$ lb **Ans**

$A_x = 25$ lb **Ans**

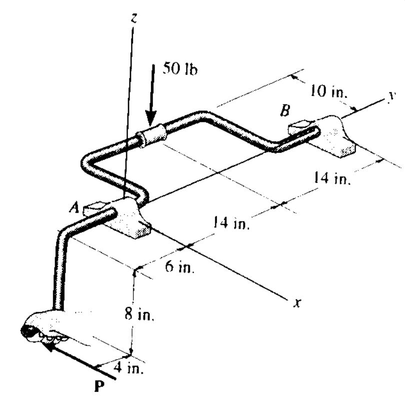
$A_y = -25$ lb **Ans**

$A_z = 50$ lb **Ans**

$B_y = 25$ lb **Ans**



5-86. A vertical force of 50 lb acts on the crankshaft. Determine the horizontal equilibrium force **P** that must be applied to the handle and the x, y, z components of reaction at the journal bearing A and thrust bearing B. The bearings are properly aligned and exert only force reactions on the shaft.



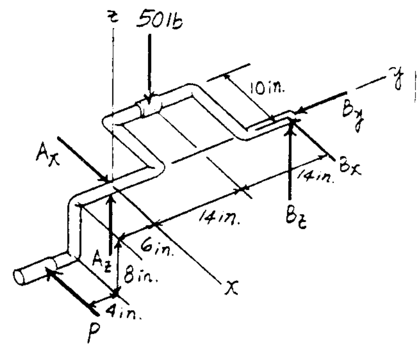
Equations of Equilibrium :

$\Sigma M_x = 0;\quad B_z(28) - 50(14) = 0 \quad B_z = 25.0 \text{ lb}$ **Ans**

$\Sigma M_y = 0;\quad P(8) - 50(10) = 0 \quad P = 62.5 \text{ lb}$ **Ans**

$\Sigma M_z = 0;\quad B_x(28) - 62.5(10) = 0$

$B_x = 22.32 \text{ lb} = 22.3 \text{ lb}$ **Ans**

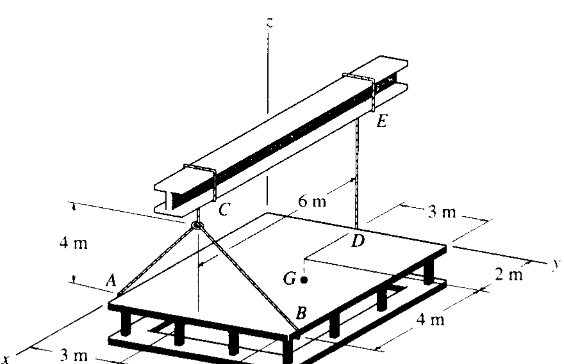


$\Sigma F_x = 0;\quad 62.5 + 22.32 - A_x = 0 \quad A_x = 84.8 \text{ lb}$ **Ans**

$\Sigma F_y = 0;\quad B_y = 0$ **Ans**

$\Sigma F_z = 0;\quad A_z + 25.0 - 50 = 0 \quad A_z = 25.0 \text{ lb}$ **Ans**

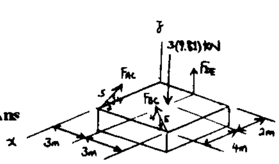
5-87. The platform has a mass of 2 Mg and center of mass located at G. If it is lifted using the three cables, determine the force in each of these cables. Solve for each force by using a single moment equation of equilibrium.



$\Sigma F_y = 0;\quad \frac{3}{4}F_{AC} - \frac{3}{4}F_{BC} = 0;\quad F_{AC} = F_{BC}$

$\Sigma M_y = 0;\quad 3(9.81)(2) - \frac{4}{5}F_{AC}(6) - \frac{4}{5}F_{BC}(6) = 0$

$F_{AC} = F_{BC} = 6.131 = 6.13 \text{ kN}$ **Ans**

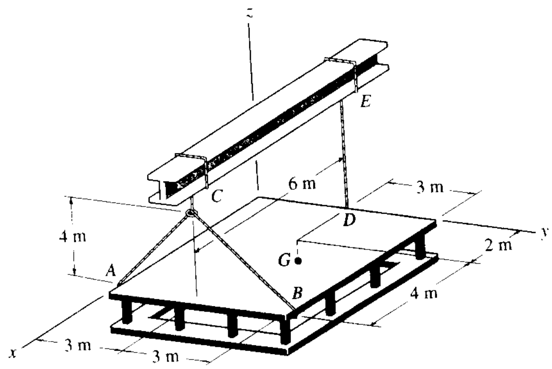


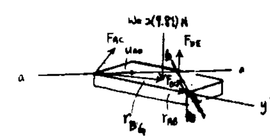
$\Sigma M_x = 0;\quad \frac{4}{5}(6.131)(6) - 3(9.81)(3) + F_{DE}(3) = 0$

$F_{DE} = 19.62 = 19.6 \text{ kN}$ **Ans**

$\Sigma F_z = 0;\quad \frac{4}{5}(6.131) + \frac{4}{5}(6.131) + 19.62 - 3(9.81) = 0$ Check !

***5-88.** The platform has a mass of 2 Mg and center of mass located at G. If it is lifted using the three cables, determine the force in each of the cables. Solve for each force by using a single moment equation of equilibrium.





$\Sigma M_{y'} = 0;$ $\quad F_{DE}(6) - 2(9.81)(4) = 0$

$F_{DE} = 13.1 \text{ kN}$ **Ans**

$\Sigma M_{aa} = 0;$ $\quad \mathbf{u}_{aa} \cdot (\mathbf{r}_{AB} \times \mathbf{F}_{BC}) + \mathbf{u}_{aa} \cdot (\mathbf{r}_{AG} \times \mathbf{W}) = 0$

$$\begin{vmatrix} -0.8944 & 0.4472 & 0 \\ 0 & 6 & 0 \\ 0 & -0.6F_{BC} & 0.8F_{BC} \end{vmatrix} + \begin{vmatrix} -0.8944 & 0.4472 & 0 \\ -4 & 3 & 0 \\ 0 & 0 & -19.62 \end{vmatrix} = 0$$

$$-0.8944(6)(0.8F_{BC}) - 0.8944(3)(-19.62) - 0.4472(-4)(-19.62) = 0$$

$F_{BC} = 4.09 \text{ kN}$ **Ans**

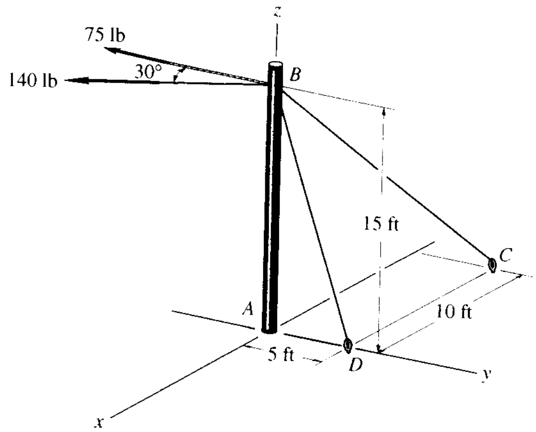
$\Sigma M_{bb} = 0;$ $\quad \mathbf{u}_{bb} \cdot (\mathbf{r}_{BA} \times \mathbf{F}_{AC}) + \mathbf{u}_{bb} \cdot (\mathbf{r}_{BG} \times \mathbf{W}) = 0$

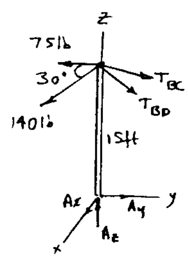
$$\begin{vmatrix} -0.8944 & -0.4472 & 0 \\ 0 & -6 & 0 \\ 0 & 0.6F_{AC} & 0.8F_{AC} \end{vmatrix} + \begin{vmatrix} -0.8944 & -0.4472 & 0 \\ -4 & -3 & 0 \\ 0 & 0 & -19.62 \end{vmatrix} = 0$$

$$-0.8944(-6)(0.8F_{AC}) - 0.8944(-3)(-19.62) + (0.4472)(-4)(-19.62) = 0$$

$F_{AC} = 4.09 \text{ kN}$ **Ans**

5-89. The cables exert the forces shown on the pole. Assuming the pole is supported by a ball-and-socket joint at its base, detemine the components of reaction at A. The forces of 140 lb and 75 lb lie in a horizontal plane.





$$\mathbf{T}_{BD} = \frac{1}{\sqrt{10}}T_{BD}\mathbf{j} - \frac{3}{\sqrt{10}}T_{BD}\mathbf{k}$$

$$\mathbf{T}_{BC} = \frac{-10}{\sqrt{350}}T_{BC}\mathbf{i} + \frac{5}{\sqrt{350}}T_{BC}\mathbf{j} - \frac{15}{\sqrt{350}}T_{BC}\mathbf{k}$$

$\Sigma M_x = 0;\quad (140\cos 30° + 75)(15) - \frac{5}{\sqrt{350}}T_{BC}(15) - \frac{1}{\sqrt{10}}T_{BD}(15) = 0$

$\Sigma M_y = 0;\quad 140\sin 30°(15) - \frac{10}{\sqrt{350}}T_{BC}(15) = 0$

$\Sigma F_x = 0;\quad A_x + 140\sin 30° - \frac{10}{\sqrt{350}}T_{BC} = 0$

$\Sigma F_y = 0;\quad A_y - 140\cos 30° - 75 + \frac{1}{\sqrt{10}}T_{BD} + \frac{5}{\sqrt{350}}T_{BC} = 0$

$\Sigma F_z = 0;\quad A_z - \frac{3}{\sqrt{10}}T_{BD} - \frac{15}{\sqrt{350}}T_{BC} = 0$

$T_{BC} = 130.96 = 131$ lb **Ans**

$T_{BD} = 510$ lb **Ans**

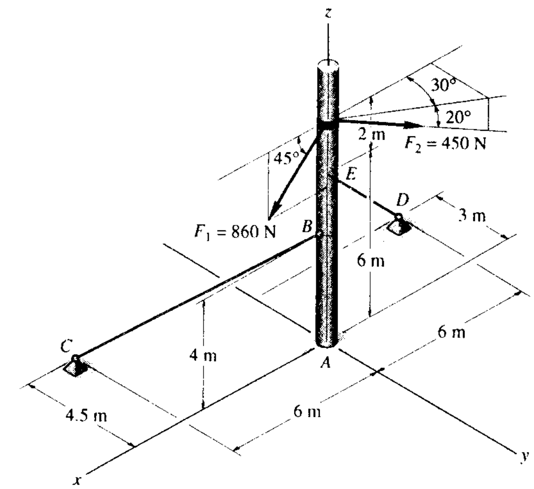
$A_x = 0$ **Ans**

$A_y = 0$ **Ans**

$A_z = 589$ lb **Ans**

Also, note that BA is a two-force member, so that $A_x = A_y = 0$.

5-90. The pole is subjected to the two forces shown. Determine the components of reaction at A assuming it to be a ball-and-socket joint. Also, compute the tension in each of the guy wires, BC and ED.



Force Vector and Position Vectors :

$$\mathbf{F}_A = A_x\mathbf{i} + A_y\mathbf{j} + A_z\mathbf{k}$$

$$\mathbf{F}_1 = 860\{\cos 45°\mathbf{i} - \sin 45°\mathbf{k}\}\ \text{N} = \{608.11\mathbf{i} - 608.11\mathbf{k}\}\ \text{N}$$

$$\mathbf{F}_2 = 450\{-\cos 20°\cos 30°\mathbf{i} + \cos 20°\sin 30°\mathbf{k} - \sin 20°\mathbf{k}\}\ \text{N}$$
$$= \{-366.21\mathbf{i} + 211.43\mathbf{j} - 153.91\mathbf{k}\}\ \text{N}$$

$$\mathbf{F}_{ED} = F_{ED}\left[\frac{(-6-0)\mathbf{i} + (-3-0)\mathbf{j} + (0-6)\mathbf{k}}{\sqrt{(-6-0)^2 + (-3-0)^2 + (0-6)^2}}\right]$$
$$= -\frac{2}{3}F_{ED}\mathbf{i} - \frac{1}{3}F_{ED}\mathbf{j} - \frac{2}{3}F_{ED}\mathbf{k}$$

$$\mathbf{F}_{BC} = F_{BC}\left[\frac{(6-0)\mathbf{i} + (-4.5-0)\mathbf{j} + (0-4)\mathbf{k}}{\sqrt{(6-0)^2 + (-4.5-0)^2 + (0-4)^2}}\right]$$
$$= \frac{12}{17}F_{BC}\mathbf{i} - \frac{9}{17}F_{BC}\mathbf{j} - \frac{8}{17}F_{BC}\mathbf{k}$$

$$\mathbf{r}_1 = \{4\mathbf{k}\}\ \text{m} \qquad \mathbf{r}_2 = \{8\mathbf{k}\}\ \text{m} \qquad \mathbf{r}_3 = \{6\mathbf{k}\}\ \text{m}$$

Equations of Equilibrium : Force equilibrium requires

$$\Sigma\mathbf{F} = 0; \qquad \mathbf{F}_A + \mathbf{F}_1 + \mathbf{F}_2 + \mathbf{F}_{ED} + \mathbf{F}_{BC} = 0$$

$$\left(A_x + 608.11 - 366.21 - \frac{2}{3}F_{ED} + \frac{12}{17}F_{BC}\right)\mathbf{i}$$
$$+\left(A_y + 211.43 - \frac{1}{3}F_{ED} - \frac{9}{17}F_{BC}\right)\mathbf{j}$$
$$+\left(A_z - 608.11 - 153.91 - \frac{2}{3}F_{ED} - \frac{8}{17}F_{BC}\right)\mathbf{k} = 0$$

Equating **i**, **j** and **k** components, we have

$$\Sigma F_x = 0; \qquad A_x + 608.11 - 366.21 - \frac{2}{3}F_{ED} + \frac{12}{17}F_{BC} = 0 \qquad [1]$$

$$\Sigma F_y = 0; \qquad A_y + 211.43 - \frac{1}{3}F_{ED} - \frac{9}{17}F_{BC} = 0 \qquad [2]$$

$$\Sigma F_z = 0; \qquad A_z - 608.11 - 153.91 - \frac{2}{3}F_{ED} - \frac{8}{17}F_{BC} = 0 \qquad [3]$$

Moment equilibrium requires

$$\Sigma\mathbf{M}_A = 0; \qquad \mathbf{r}_1 \times \mathbf{F}_{BC} + \mathbf{r}_2 \times (\mathbf{F}_1 + \mathbf{F}_2) + \mathbf{r}_3 \times \mathbf{F}_{ED} = 0$$

$$4\mathbf{k} \times \left(\frac{12}{17}F_{BC}\mathbf{i} - \frac{9}{17}F_{BC}\mathbf{j} - \frac{8}{17}F_{BC}\mathbf{k}\right)$$
$$+ 8\mathbf{k} \times (241.90\mathbf{i} + 211.43\mathbf{j} - 762.02\mathbf{k})$$
$$+ 6\mathbf{k} \times \left(-\frac{2}{3}F_{ED}\mathbf{i} - \frac{1}{3}F_{ED}\mathbf{j} - \frac{2}{3}F_{ED}\mathbf{k}\right) = 0$$

Equating **i**, **j** and **k** components, we have

$$\Sigma M_x = 0; \qquad \frac{36}{17}F_{BC} + 2F_{ED} - 1691.45 = 0 \qquad [4]$$

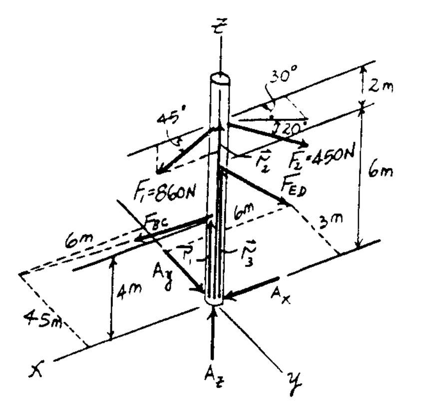
$$\Sigma M_y = 0; \qquad \frac{48}{17}F_{BC} - 4F_{ED} + 1935.22 = 0 \qquad [5]$$

Solving Eqs. [4] and [5] yields

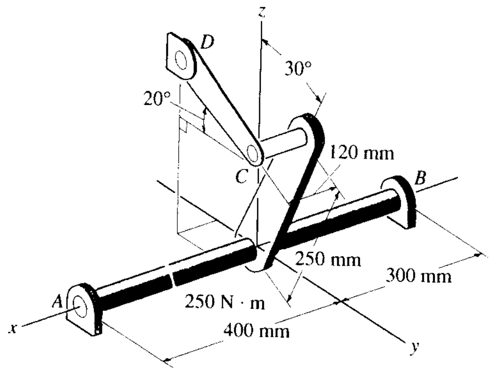
$$F_{BC} = 205.09\ \text{N} = 205\ \text{N} \qquad F_{ED} = 628.57\ \text{N} = 629\ \text{N} \qquad \textbf{Ans}$$

Substituting the results into Eqs. [1], [2] and [3] yields

$$A_x = 32.4\ \text{N} \qquad A_y = 107\ \text{N} \qquad A_z = 1277.58\ \text{N} = 1.28\ \text{kN} \qquad \textbf{Ans}$$



*5-91. The shaft assembly is supported by two smooth journal bearings A and B and a short link DC. If a couple moment is applied to the shaft as shown, determine the components of force reaction at the bearings and the force in the link. The link lies in a plane parallel to the y-z plane and the bearings are properly aligned on the shaft.



$\Sigma M_x = 0;\quad -250 + F_{CD}\cos 20°(0.25\cos 30°) + F_{CD}\sin 20°(0.25\sin 30°) = 0$

$F_{CD} = 1015.43 \text{ N} = 1.02 \text{ kN}$ **Ans**

$\Sigma(M_B)_y = 0;\quad -A_z(0.7) - 1015.43\sin 20°(0.42) = 0$

$A_z = -208.38 = -208 \text{ N}$ **Ans**

$\Sigma F_z = 0;\quad -208.38 + 1015.43\sin 20° + B_z = 0$

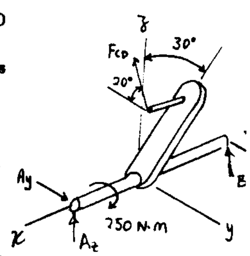
$B_z = -139 \text{ N}$ **Ans**

$\Sigma(M_B)_z = 0;\quad A_y(0.7) - 1015.43\cos 20°(0.42) = 0$

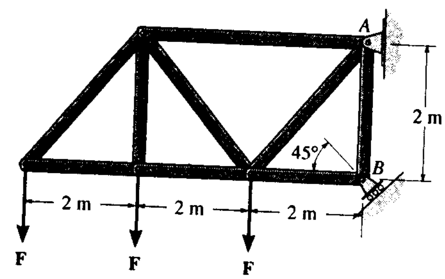
$A_y = 572.51 = 573 \text{ N}$ **Ans**

$\Sigma F_y = 0;\quad 572.51 - 1015.43\cos 20° + B_y = 0$

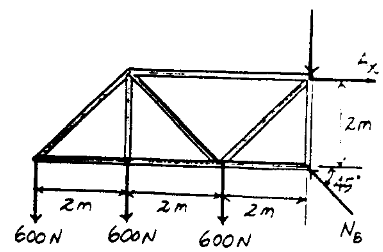
$B_y = 382 \text{ N}$ **Ans**



5-92. Determine the horizontal and vertical components of reaction at the pin A and the reaction at the roller B required to support the truss. Set $F = 600$ N.



Equations of Equilibrium : The normal reaction N_B can be obtained directly by summing moments about point A.



$\curvearrowleft + \Sigma M_A = 0;$ $\quad 600(6) + 600(4) + 600(2) - N_B \cos 45°(2) = 0$

$N_B = 5091.17 \text{ N} = 5.09 \text{ kN}$ **Ans**

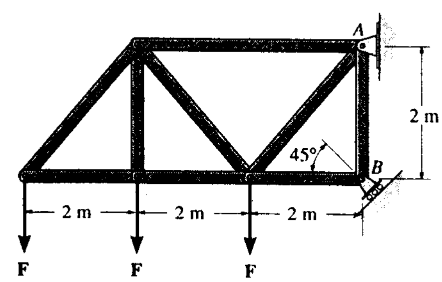
$\overset{+}{\rightarrow} \Sigma F_x = 0;$ $\quad A_x - 5091.17\cos 45° = 0$

$A_x = 3600 \text{ N} = 3.60 \text{ kN}$ **Ans**

$+\uparrow \Sigma F_y = 0;$ $\quad 5091.17\sin 45° - 3(600) - A_y = 0$

$A_y = 1800 \text{ N} = 1.80 \text{ kN}$ **Ans**

5-93. If the roller at B can sustain a maximum load of 3 kN, determine the largest magnitude of each of the three forces **F** that can be supported by the truss.

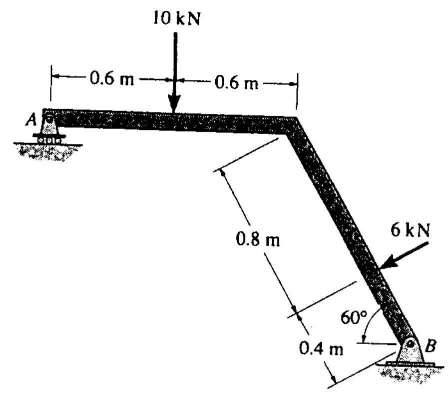


Equations of Equilibrium : The unknowns A_x and A_y can be eliminated by summing moments about point A.

$\curvearrowleft + \Sigma M_A = 0;$ $\quad F(6) + F(4) + F(2) - 3\cos 45°(2) = 0$

$F = 0.3536 \text{ kN} = 354\text{N}$ **Ans**

5-94. Determine the normal reaction at the roller A and horizontal and vertical components at pin B for equilibrium of the member.



Equations of Equilibrium : The normal reaction N_A can be obtained directly by summing moments about point B.

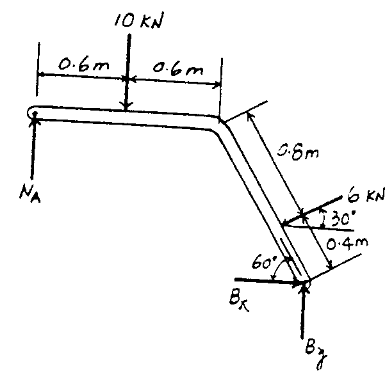
$$\curvearrowleft + \Sigma M_A = 0; \quad 10(0.6 + 1.2\cos 60°) + 6(0.4) - N_A(1.2 + 1.2\cos 60°) = 0$$

$$N_A = 8.00 \text{ kN} \qquad \textbf{Ans}$$

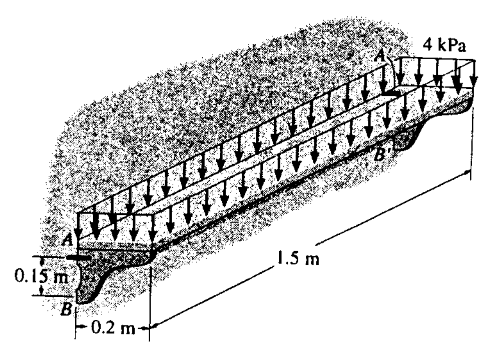
$$\xrightarrow{+} \Sigma F_x = 0; \quad B_x - 6\cos 30° = 0 \quad B_x = 5.20 \text{ kN} \qquad \textbf{Ans}$$

$$+\uparrow \Sigma F_y = 0; \quad B_y + 8.00 - 6\sin 30° - 10 = 0$$

$$B_y = 5.00 \text{ kN} \qquad \textbf{Ans}$$



***5-95.** The symmetrical shelf is subjected to a uniform load of 4 kPa. Support is provided by a bolt (or pin) located at each end A and A' and by the symmetrical brace arms, which bear against the smooth wall on both sides at B and B'. Determine the force resisted by each bolt at the wall and the normal force at B for equilibrium.



Equations of Equilibrium : Each shelf's post at its end supports half of the applied load, ie, $4000(0.2)(0.75) = 600$ N. The normal reaction N_B can be obtained directly by summing moments about point A.

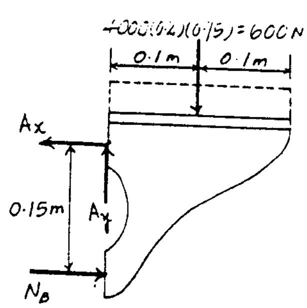
$$\curvearrowleft + \Sigma M_A = 0; \quad N_B(0.15) - 600(0.1) = 0 \quad N_B = 400 \text{ N} \qquad \textbf{Ans}$$

$$\xrightarrow{+} \Sigma F_x = 0; \quad 400 - A_x = 0 \quad A_x = 400\text{N}$$

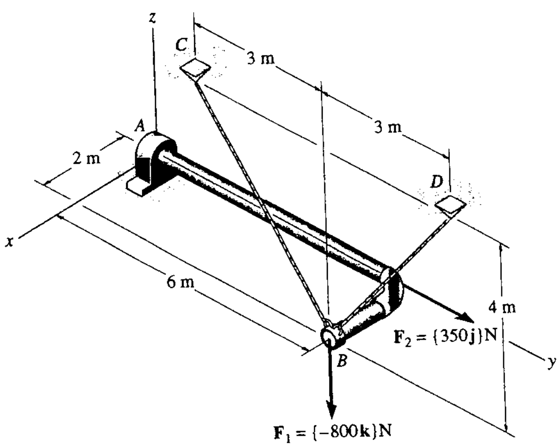
$$+\uparrow \Sigma F_y = 0; \quad A_y - 600 = 0 \quad A_y = 600 \text{ N}$$

The force resisted by the bolt at A is

$$F_A = \sqrt{A_x^2 + A_y^2} = \sqrt{400^2 + 600^2} = 721 \text{ N} \qquad \textbf{Ans}$$

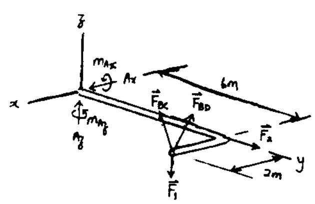


5-96. Determine the x and z components of reaction at the journal bearing A and the tension in cords BC and BD necessary for equilibrium of the rod.



$\mathbf{F}_1 = \{-800\mathbf{k}\}$ N

$\mathbf{F}_2 = \{350\mathbf{j}\}$ N



$$\mathbf{F}_{BC} = F_{BC}\frac{(-3\mathbf{j} + 4\mathbf{k})}{5}$$

$$= \{-0.6F_{BC}\mathbf{j} + 0.8F_{BC}\mathbf{k}\}\text{ N}$$

$$\mathbf{F}_{BD} = F_{BD}\frac{(3\mathbf{j} + 4\mathbf{k})}{5}$$

$$= \{0.6F_{BD}\mathbf{j} + 0.8F_{BD}\mathbf{k}\}\text{ N}$$

$\Sigma F_x = 0;\quad A_x = 0$ **Ans**

$\Sigma F_y = 0;\quad 350 - 0.6F_{BC} + 0.6F_{BD} = 0$

$\Sigma F_z = 0;\quad A_z - 800 + 0.8F_{BC} + 0.8F_{BD} = 0$

$\Sigma M_x = 0;\quad M_{Ax} + 0.8F_{BD}(6) + 0.8F_{BC}(6) - 800(6) = 0$

$\Sigma M_y = 0;\quad 800(2) - 0.8F_{BC}(2) - 0.8F_{BD}(2) = 0$

$\Sigma M_z = 0;\quad M_{Az} - 0.6F_{BC}(2) + 0.6F_{BD}(2) = 0$

$F_{BD} = 208$ N **Ans**

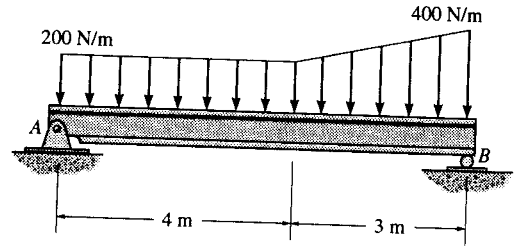
$F_{BC} = 792$ N **Ans**

$A_z = 0$ **Ans**

$M_{Ax} = 0$ **Ans**

$M_{Az} = 700$ N·m **Ans**

5-97. Determine the reactions at the supports A and B for equilibrium of the beam.



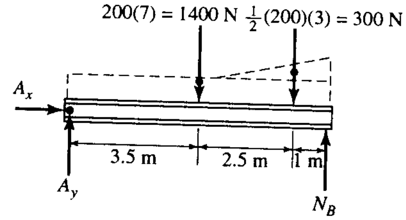
Equations of Equilibrium: The normal reaction N_B can be obtained directly by summing moments about point A.

$+\Sigma M_A = 0;\quad N_B(7) - 1400(3.5) - 300(6) = 0$

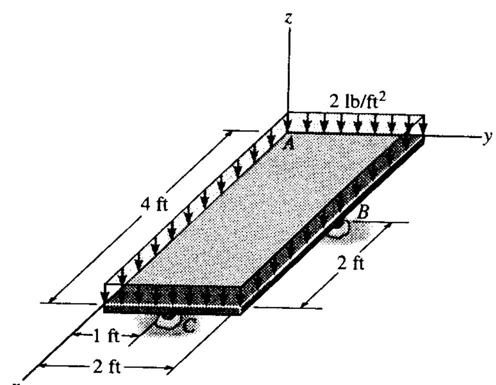
$N_B = 957.14\text{ N} = 957\text{ N}$ **Ans**

$Ag - 1400 - 300 + 957 = 0 \qquad Ag = 743\text{ N}$

$\overset{+}{\rightarrow}\Sigma F_x = 0;\quad A_x = 0$ **Ans**



5-98. Determine the x, y, z components of reaction at the ball supports B and C and the ball-and-socket A (not shown) for the uniformly loaded plate.



$W = (4\text{ ft})(2\text{ ft})(2\text{ lb/ft}^2) = 16\text{ lb}$

$\Sigma F_x = 0;\quad A_x = 0$ **Ans**

$\Sigma F_y = 0;\quad A_y = 0$ **Ans**

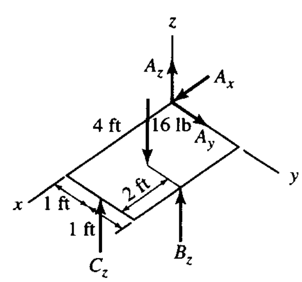
$\Sigma F_z = 0;\quad A_z + B_z + C_z - 16 = 0 \qquad (1)$

$\Sigma M_x = 0;\quad 2B_z - 16(1) + C_z(1) = 0 \qquad (2)$

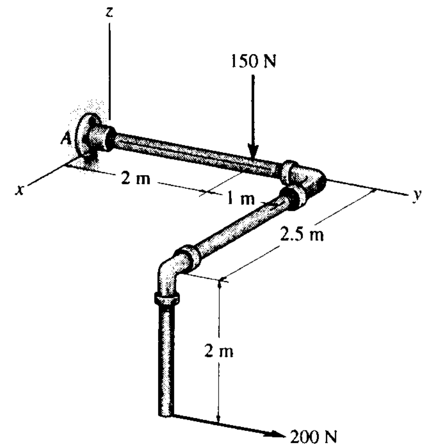
$\Sigma M_y = 0;\quad -B_z(2) + 16(2) - C_z(4) = 0 \qquad (3)$

Solving Eqs. (1)–(3):

$A_z = B_z = C_z = 5.33\text{ lb}$ **Ans**



*5-99. Determine the x, y, z components of reaction at the fixed wall A. The 150-N force is parallel to the z axis and the 200-N force is parallel to the y axis.



Equations of Equilibrium :

$\Sigma F_x = 0;\quad A_x = 0$ **Ans**

$\Sigma F_y = 0;\quad A_y + 200 = 0 \quad A_y = -200\text{ N}$ **Ans**

$\Sigma F_z = 0;\quad A_z - 150 = 0 \quad A_z = 150\text{ N}$ **Ans**

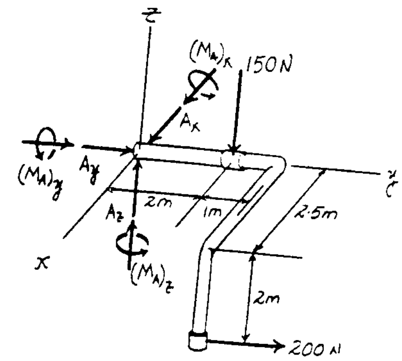
$\Sigma M_x = 0;\quad (M_A)_x + 200(2) - 150(2) = 0$

$(M_A)_x = -100\text{ N}\cdot\text{m}$ **Ans**

$\Sigma M_y = 0;\quad (M_A)_y = 0$ **Ans**

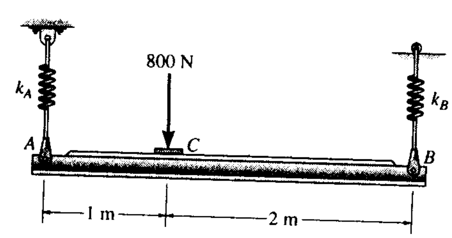
$\Sigma M_z = 0;\quad (M_A)_z + 200(2.5) = 0$

$(M_A)_z = -500\text{ N}\cdot\text{m}$ **Ans**



The negative signs indicate that the direction of the reaction components are in the opposite sense of those shown on FBD.

5-100. The horizontal beam is supported by springs at its ends. If the stiffness of the spring at A is $k_A = 5$ kN/m, determine the required stiffness of the spring at B so that if the beam is loaded with the 800-N force, it remains in the horizontal position both before and after loading.

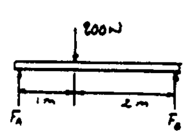


Equilibrium :

$\curvearrowleft+\Sigma M_A = 0;\quad F_B(3) - 800(1) = 0 \quad F_B = 266.67\text{ N}$

$\curvearrowleft+\Sigma M_B = 0;\quad 800(2) - F_A(3) = 0 \quad F_A = 533.33\text{ N}$

Spring force formula : $x = \dfrac{F}{k}$

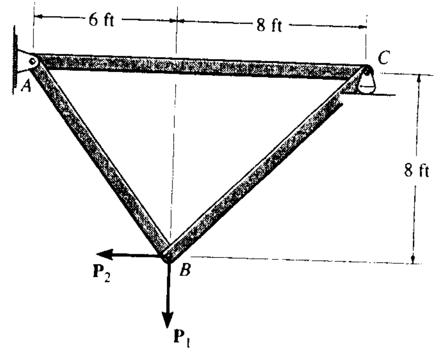


$x_A = x_B$

$\dfrac{533.33}{5000} = \dfrac{266.67}{k_B}$

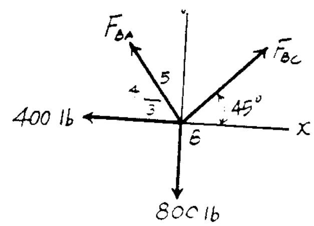
$k_B = 2500\text{ N/m} = 2.50\text{ kN/m}$ **Ans**

6-1. Determine the force in each member of the truss and state if the members are in tension or compression. Set $P_1 = 800$ lb and $P_2 = 400$ lb.



Method of Joints : In this case, the support reactions are not required for determining the member forces.

Joint *B*



$\xrightarrow{+} \Sigma F_x = 0;\quad F_{BC}\cos 45° - F_{BA}\left(\frac{3}{5}\right) - 400 = 0$ [1]

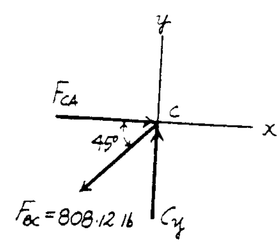
$+\uparrow \Sigma F_y = 0;\quad F_{BC}\sin 45° + F_{BA}\left(\frac{4}{5}\right) - 800 = 0$ [2]

Solving Eqs. [1] and [2] yields

$F_{BA} = 285.71$ lb (T) $= 286$ lb (T) **Ans**

$F_{BC} = 808.12$ lb (T) $= 808$ lb (T) **Ans**

Joint *C*



$\xrightarrow{+} \Sigma F_x = 0;\quad F_{CA} - 808.12\cos 45° = 0$

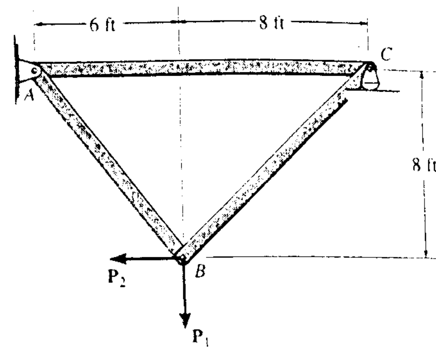
$F_{CA} = 571$ lb (C) **Ans**

$+\uparrow \Sigma F_y = 0;\quad C_y - 808.12\sin 45° = 0$

$C_y = 571$ lb

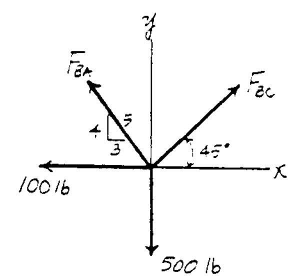
Note : The support reactions A_x and A_y can be determined by analyzing Joint *A* using the results obtained above.

6-2. Determine the force on each member of the truss and state if the members are in tension or compression. Set $P_1 = 500$ lb and $P_2 = 100$ lb.



Method of Joints : In this case, the support reactions are not required for determining the member forces.

Joint *B*



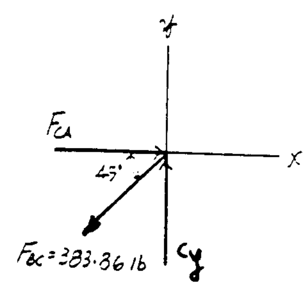
$$\xrightarrow{+} \Sigma F_x = 0; \quad F_{BC}\cos 45° - F_{BA}\left(\frac{3}{5}\right) - 100 = 0 \qquad [1]$$

$$+\uparrow \Sigma F_y = 0; \quad F_{BC}\sin 45° + F_{BA}\left(\frac{4}{5}\right) - 500 = 0 \qquad [2]$$

Solving Eqs. [1] and [2] yields

$$F_{BA} = 285.71 \text{ lb (T)} = 286 \text{ lb (T)} \qquad \textbf{Ans}$$
$$F_{BC} = 383.86 \text{ lb (T)} = 384 \text{ lb (T)} \qquad \textbf{Ans}$$

Joint *C*

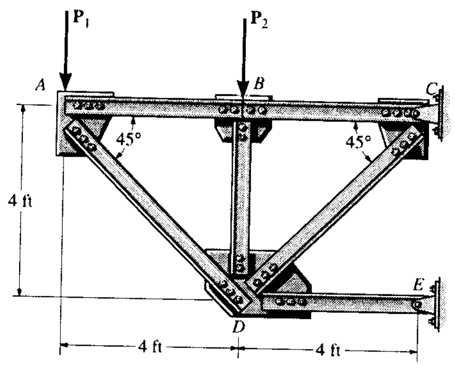


$$\xrightarrow{+} \Sigma F_x = 0; \quad F_{CA} - 383.86\cos 45° = 0$$
$$F_{CA} = 271 \text{ lb (C)} \qquad \textbf{Ans}$$

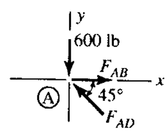
$$+\uparrow \Sigma F_y = 0; \quad C_y - 383.86\sin 45° = 0$$
$$C_y = 271.43 \text{ lb}$$

Note : The support reactions A_x and A_y can be determined by analyzing Joint A using the results obtained above.

6-3. The truss, used to support a balcony, is subjected to the loading shown. Approximate each joint as a pin and determine the force in each member. State whether the members are in tension or compression. Set $P_1 = 600$ lb, $P_2 = 400$ lb.



Joint A:



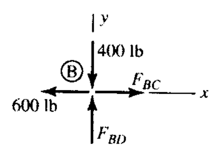
$+\uparrow \Sigma F_y = 0;\quad F_{AD}\sin 45^\circ - 600 = 0$

$F_{AD} = 848.528 = 849$ lb(C) **Ans**

$\overset{+}{\rightarrow} \Sigma F_x = 0;\quad F_{AB} - 848.528\cos 45^\circ = 0$

$F_{AB} = 600$ lb(T) **Ans**

Joint B:



$+\uparrow \Sigma F_y = 0;\quad F_{BD} - 400 = 0$

$F_{BD} = 400$ lb(C) **Ans**

$\overset{+}{\rightarrow} \Sigma F_x = 0;\quad F_{BC} - 600 = 0$

$F_{BC} = 600$ lb(T) **Ans**

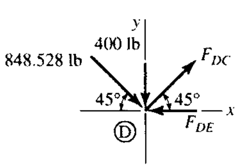
Joint D:

$+\uparrow \Sigma F_y = 0;\quad F_{DC}\sin 45^\circ - 400 - 848.528\sin 45^\circ = 0$

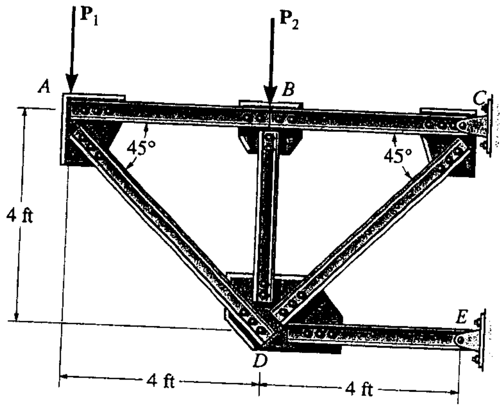
$F_{DC} = 1414.214$ lb $= 1.41$ kip(T) **Ans**

$\overset{+}{\rightarrow} \Sigma F_x = 0;\quad 848.528\cos 45^\circ + 1414.214\cos 45^\circ - F_{DE} = 0$

$F_{DE} = 1600$ lb $= 1.60$ kip(C) **Ans**



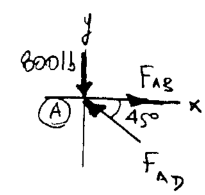
***6-4.** The truss, used to support a balcony, is subjected to the loading shown. Approximate each joint as a pin and determine the force in each member. State whether the members are in tension or compression. Set $P_1 = 800$ lb, $P_2 = 0$.



Joint A :

$+\uparrow \Sigma F_y = 0;$ $\quad F_{AD}\sin 45° - 800 = 0$

$F_{AD} = 1131.4 \text{ lb} = 1.13 \text{ kip (C)}$ **Ans**



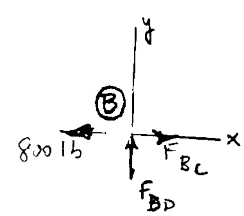
$\xrightarrow{+} \Sigma F_x = 0;$ $\quad F_{AB} - 1131.4\cos 45° = 0$

$F_{AB} = 800 \text{ lb (T)}$ **Ans**

Joint B :

$+\uparrow \Sigma F_y = 0;$ $\quad F_{BD} - 0 = 0$

$F_{BD} = 0$ **Ans**



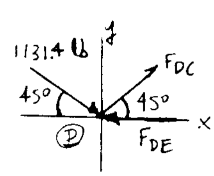
$\xrightarrow{+} \Sigma F_x = 0;$ $\quad F_{BC} - 800 = 0$

$F_{BC} = 800 \text{ lb (T)}$ **Ans**

Joint D :

$+\uparrow \Sigma F_y = 0;$ $\quad F_{DC}\sin 45° - 0 - 1131.4\sin 45° = 0$

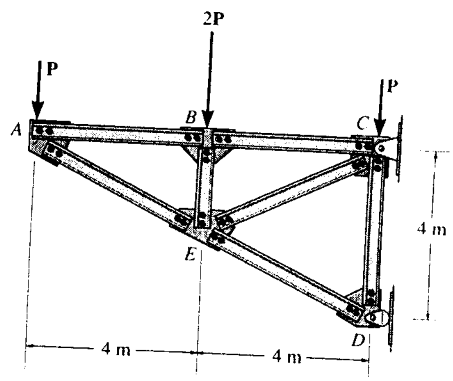
$F_{DC} = 1131.4 \text{ lb} = 1.13 \text{ kip (T)}$ **Ans**



$\xrightarrow{+} \Sigma F_x = 0;$ $\quad 1131.4\cos 45° + 1131.4\cos 45° - F_{DE} = 0$

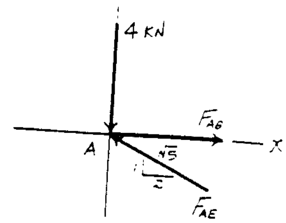
$F_{DE} = 1600 \text{ lb} = 1.60 \text{ kip (C)}$ **Ans**

6-5. Determine the force in each member of the truss and state if the members are in tension or compression. Assume each joint as a pin. Set $P = 4$ kN.



Method of Joints : In this case, the support reactions are not required for determining the member forces.

Joint *A*



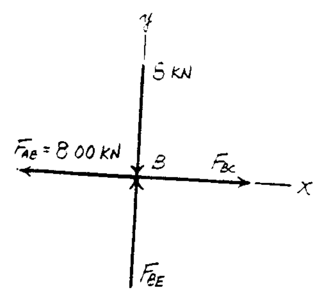
$+\uparrow \Sigma F_y = 0; \quad F_{AE}\left(\frac{1}{\sqrt{5}}\right) - 4 = 0$

$F_{AE} = 8.944$ kN (C) $= 8.94$ kN (C) **Ans**

$\xrightarrow{+} \Sigma F_x = 0; \quad F_{AB} - 8.944\left(\frac{2}{\sqrt{5}}\right) = 0$

$F_{AB} = 8.00$ kN (T) **Ans**

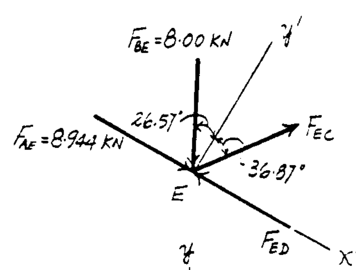
Joint *B*



$\xrightarrow{+} \Sigma F_x = 0; \quad F_{BC} - 8.00 = 0 \quad F_{BC} = 8.00$ kN (T) **Ans**

$+\uparrow \Sigma F_y = 0; \quad F_{BE} - 8 = 0 \quad F_{BE} = 8.00$ kN (C) **Ans**

Joint *E*



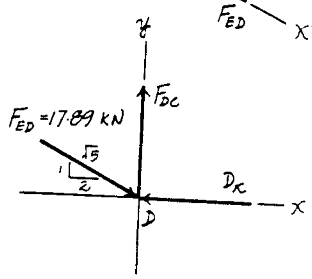
$+ \Sigma F_{y'} = 0; \quad F_{EC}\cos 36.87° - 8.00\cos 26.57° = 0$

$F_{EC} = 8.944$ kN (T) $= 8.94$ kN (T) **Ans**

$+\Sigma F_{x'} = 0; \quad 8.944 + 8.00\sin 26.57° + 8.944\sin 36.87° - F_{ED} = 0$

$F_{ED} = 17.89$ kN (C) $= 17.9$ kN (C) **Ans**

Joint *D*

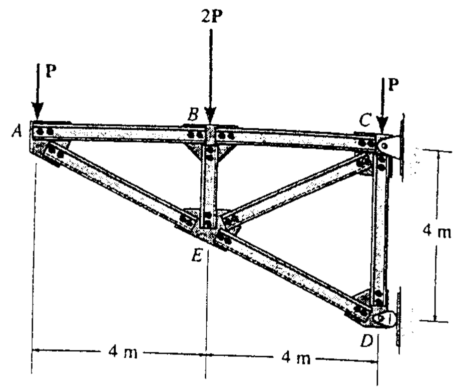


$+\uparrow \Sigma F_y = 0; \quad F_{DC} - 17.89\left(\frac{1}{\sqrt{5}}\right) = 0 \quad F_{DC} = 8.00$ kN (T) **Ans**

$\xrightarrow{+} \Sigma F_x = 0; \quad -D_x + 17.89\left(\frac{2}{\sqrt{5}}\right) = 0 \quad D_x = 16.0$ kN

Note : The support reactions C_x and C_y can be determined by analysing Joint C using the results obtained above.

6-6. Assume that each member of the truss is made of steel having a mass per length of 4 kg/m. Set $P = 0$, determine the force in each member, and indicate if the members are in tension or compression. Neglect the weight of the gusset plates and assume each joint is a pin. Solve the problem by assuming the weight of each member can be represented as a vertical force, half of which is applied at the end of each member.



Joint Forces :

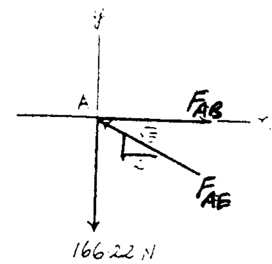
$$F_A = 4(9.81)\left(2+\frac{\sqrt{20}}{2}\right) = 166.22 \text{ N}$$

$$F_B = 4(9.81)(2+2+1) = 196.2 \text{ N}$$

$$F_E = 4(9.81)\left[1+3\left(\frac{\sqrt{20}}{2}\right)\right] = 302.47 \text{ N}$$

$$F_D = 4(9.81)\left(2+\frac{\sqrt{20}}{2}\right) = 166.22 \text{ N}$$

Method of Joints : In this case, the support reactions are not required for determining the member forces.



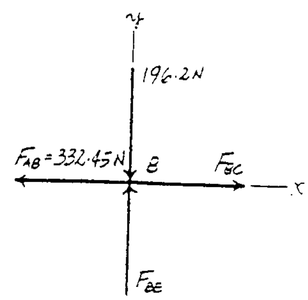
Joint A

$+\uparrow \Sigma F_y = 0;\quad F_{AE}\left(\frac{1}{\sqrt{5}}\right) - 166.22 = 0$

$F_{AE} = 371.69 \text{ N (C)} = 372 \text{ N (C)}$ **Ans**

$\overset{+}{\rightarrow} \Sigma F_x = 0;\quad F_{AB} - 371.69\left(\frac{2}{\sqrt{5}}\right) = 0$

$F_{AB} = 332.45 \text{ N (T)} = 332 \text{ N (T)}$ **Ans**

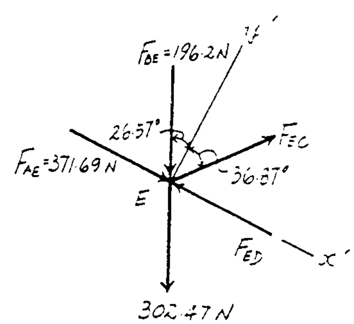


Joint B

$\overset{+}{\rightarrow} \Sigma F_x = 0;\quad F_{BC} - 332.45 = 0 \quad F_{BC} = 332 \text{ N (T)}$ **Ans**

$+\uparrow \Sigma F_y = 0;\quad F_{BE} - 196.2 = 0$

$F_{BE} = 196.2 \text{ N (C)} = 196 \text{ N (C)}$ **Ans**



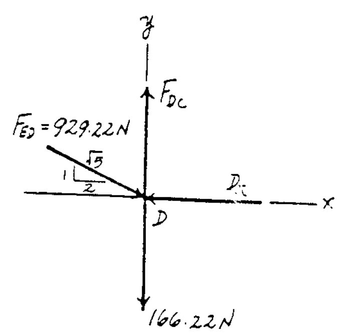
Joint E

$\nearrow{+} \Sigma F_{y'} = 0;\quad F_{EC}\cos 36.87° - (196.2 + 302.47)\cos 26.57° = 0$

$F_{EC} = 557.53 \text{ N (T)} = 558 \text{ N (T)}$ **Ans**

$\searrow{+} \Sigma F_{x'} = 0;\quad 371.69 + (196.2 + 302.47)\sin 26.57° + 557.53\sin 36.87° - F_{ED} = 0$

$F_{ED} = 929.22 \text{ N (C)} = 929 \text{ N (C)}$ **Ans**



Joint D

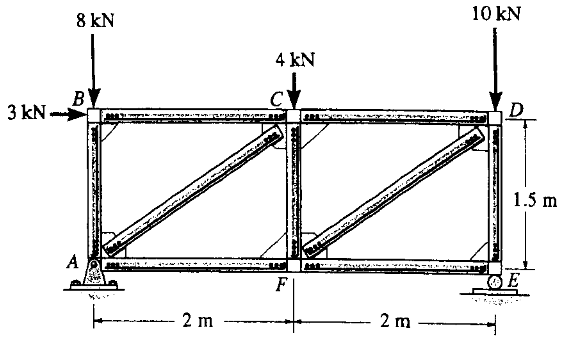
$+\uparrow \Sigma F_y = 0;\quad F_{DC} - 929.22\left(\frac{1}{\sqrt{5}}\right) - 166.22 = 0$

$F_{DC} = 582 \text{ N (T)}$ **Ans**

$\overset{+}{\rightarrow} \Sigma F_x = 0;\quad D_x - 929.22\left(\frac{2}{\sqrt{5}}\right) = 0 \quad D_x = 831.12 \text{ N}$

Note : The support reactions C_x and C_y can be determined by analyzing Joint C using the results obtained above.

6-7. Determine the force in each member of the truss and state if the members are in tension or compression.



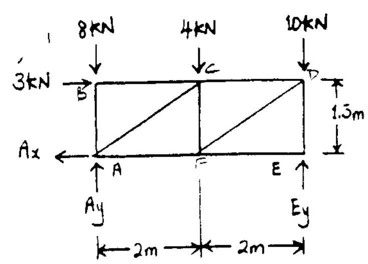
$\circlearrowleft + \Sigma M_A = 0; \quad -3(1.5) - 4(2) - 10(4) + E_y(4) = 0$

$E_y = 13.125 \text{ kN}$

$+\uparrow \Sigma F_y = 0; \quad A_y - 8 - 4 - 10 + 13.125 = 0$

$A_y = 8.875 \text{ kN}$

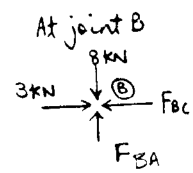
$\overset{+}{\rightarrow} \Sigma F_x = 0; \quad A_x = 3 \text{ kN}$



Joint B :

$\overset{+}{\rightarrow} \Sigma F_x = 0; \quad F_{BC} = 3 \text{ kN (C)}$ **Ans**

$+\uparrow \Sigma F_y = 0; \quad F_{BA} = 8 \text{ kN (C)}$ **Ans**



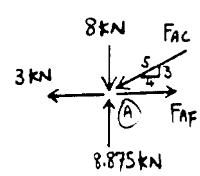
Joint A :

$+\uparrow \Sigma F_y = 0; \quad 8.875 - 8 - \frac{3}{5} F_{AC} = 0$

$F_{AC} = 1.458 = 1.46 \text{ kN (C)}$ **Ans**

$\overset{+}{\rightarrow} \Sigma F_x = 0; \quad F_{AF} - 3 - \frac{4}{5}(1.458) = 0$

$F_{AF} = 4.17 \text{ kN (T)}$ **Ans**

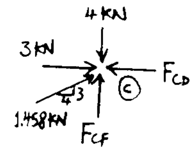


6-7 cont'd

Joint C:

$\overset{+}{\rightarrow}\Sigma F_x = 0;$ $3 + \frac{4}{5}(1.458) - F_{CD} = 0$

$F_{CD} = 4.167 = 4.17 \text{ kN (C)}$ **Ans**

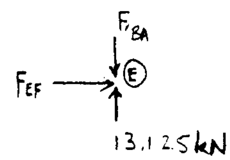


$+\uparrow\Sigma F_y = 0;$ $F_{CF} - 4 + \frac{3}{5}(1.458) = 0$

$F_{CF} = 3.125 = 3.12 \text{ kN (C)}$ **Ans**

Joint E:

$\overset{+}{\rightarrow}\Sigma F_x = 0;$ $F_{EF} = 0$ **Ans**



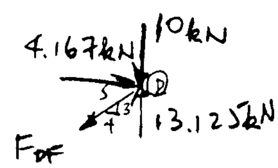
$+\uparrow\Sigma F_y = 0;$ $F_{ED} = 13.125 = 13.1 \text{ kN (C)}$ **Ans**

Joint D:

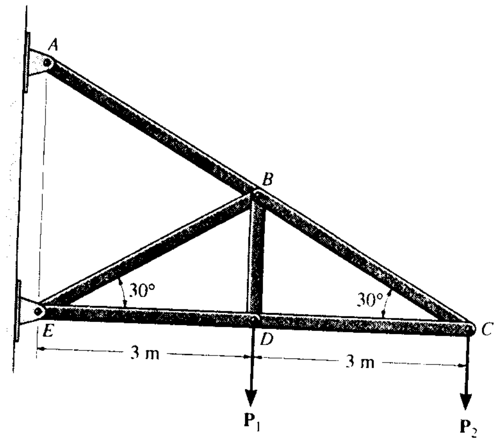
$+\uparrow\Sigma F_y = 0;$ $13.125 - 10 - \frac{3}{5}F_{DF} = 0$

$F_{DF} = 5.21 \text{ kN (T)}$ **Ans**

$\overset{+}{\rightarrow}\Sigma F_x = 0;$ $4.167 - \frac{4}{5}(5.21) = 0$ Check!

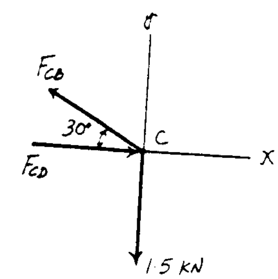


*6-8. Determine the force in each member of the truss and state if the members are in tension or compression. Set $P_1 = 2$ kN and $P_2 = 1.5$ kN.



Method of Joints : In this case, the support reactions are not required for determining the member forces.

Joint *C*



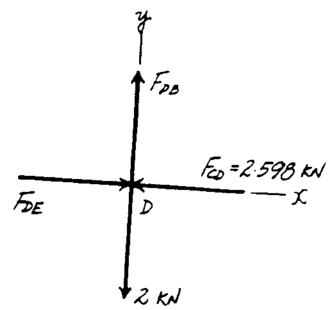
$+\uparrow \Sigma F_y = 0;\quad F_{CB} \sin 30° - 1.5 = 0$

$F_{CB} = 3.00 \text{ kN (T)}$ **Ans**

$\xrightarrow{+} \Sigma F_x = 0;\quad F_{CD} - 3.00 \cos 30° = 0$

$F_{CD} = 2.598 \text{ kN (C)} = 2.60 \text{ kN (C)}$ **Ans**

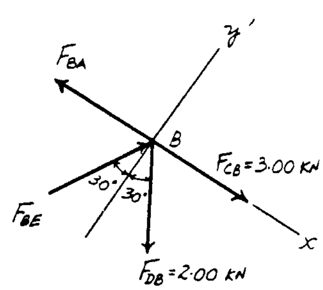
Joint *D*



$\xrightarrow{+} \Sigma F_x = 0;\quad F_{DE} - 2.598 = 0 \quad F_{DE} = 2.60 \text{ kN (C)}$ **Ans**

$+\uparrow \Sigma F_y = 0;\quad F_{DB} - 2 = 0 \quad F_{DB} = 2.00 \text{ kN (T)}$ **Ans**

Joint *B*



$+\nearrow \Sigma F_{y'} = 0;\quad F_{BE} \cos 30° - 2.00 \cos 30° = 0$

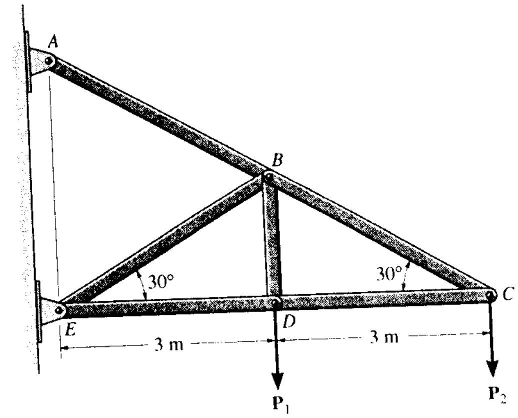
$F_{BE} = 2.00 \text{ kN (C)}$ **Ans**

$+\searrow \Sigma F_{x'} = 0;\quad (2.00 + 2.00) \sin 30° + 3.00 - F_{BA} = 0$

$F_{BA} = 5.00 \text{ kN (T)}$ **Ans**

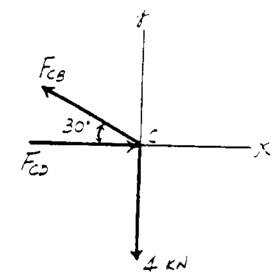
Note : The support reactions at support *A* and *E* can be determined by analyzing Joints *A* and *E* respectively using the results obtained above.

6-9. Determine the force in each member of the truss and state if the members are in tension or compression. Set $P_1 = P_2 = 4$ kN.



Method of Joints : In this case, the support reactions are not required for determining the member forces.

Joint C



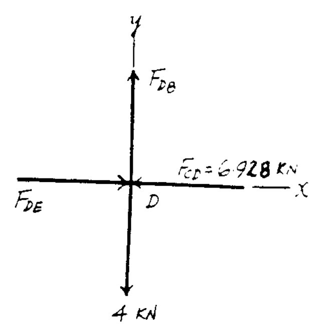
$+\uparrow \Sigma F_y = 0; \quad F_{CB} \sin 30° - 4 = 0$

$F_{CB} = 8.00$ kN (T) **Ans**

$\xrightarrow{+} \Sigma F_x = 0; \quad F_{CD} - 8.00 \cos 30° = 0$

$F_{CD} = 6.928$ kN (C) $= 6.93$ kN (C) **Ans**

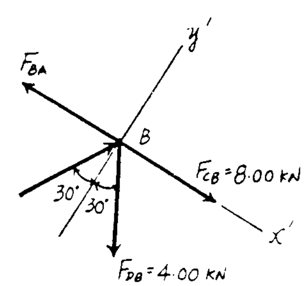
Joint D



$\xrightarrow{+} \Sigma F_x = 0; \quad F_{DE} - 6.928 = 0 \quad F_{DE} = 6.93$ kN (C) **Ans**

$+\uparrow \Sigma F_y = 0; \quad F_{DB} - 4 = 0 \quad F_{DB} = 4.00$ kN (T) **Ans**

Joint B



$\nearrow + \Sigma F_{y'} = 0; \quad F_{BE} \cos 30° - 4.00 \cos 30° = 0$

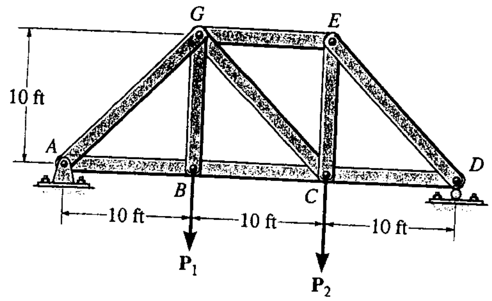
$F_{BE} = 4.00$ kN (C) **Ans**

$\searrow + \Sigma F_{x'} = 0; \quad (4.00 + 4.00) \sin 30° + 8.00 - F_{BA} = 0$

$F_{BA} = 12.0$ kN (T) **Ans**

Note : The support reactions at support *A* and *E* can be determined by analyzing Joints *A* and *E* respectively using the results obtained above.

6-10. Determine the force in each member of the truss and state if the members are in tension or compression. Set $P_1 = 0$, $P_2 = 1000$ lb.



Reactions at A and D :

$$A_x = 0$$

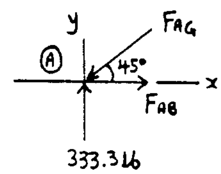
$$A_y = 333.3 \text{ lb}$$

$$D_y = 666.7 \text{ lb}$$

Joint A :

$\overset{+}{\rightarrow}\Sigma F_x = 0;$ $\quad F_{AB} - F_{AG}\cos 45° = 0$

$+\uparrow \Sigma F_y = 0;$ $\quad 333.3 - F_{AG}\sin 45° = 0$



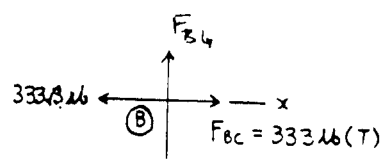
$F_{AG} = 471$ lb (C) **Ans**

$F_{AB} = 333$ lb (T) **Ans**

Joint B :

$F_{BG} = 0$ **Ans**

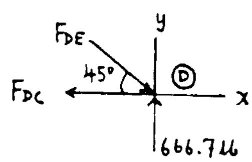
$F_{BC} = 333$ lb (T) **Ans**



Joint D :

$\overset{+}{\rightarrow}\Sigma F_x = 0;$ $\quad -F_{DC} + F_{DE}\cos 45° = 0$

$+\uparrow \Sigma F_y = 0;$ $\quad 666.7 - F_{DE}\sin 45° = 0$



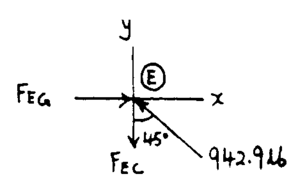
$F_{DE} = 942.9 = 943$ lb (C) **Ans**

$F_{DC} = 666.7 = 667$ lb (T) **Ans**

Joint E :

$\overset{+}{\rightarrow}\Sigma F_x = 0;$ $\quad F_{EG} - 942.9\sin 45° = 0$

$+\uparrow \Sigma F_y = 0;$ $\quad -F_{EC} + 942.9\cos 45° = 0$

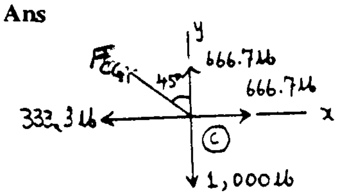


$F_{EC} = 666.7 = 667$ lb (T) **Ans**

$F_{EG} = 666.7 = 667$ lb (C) **Ans**

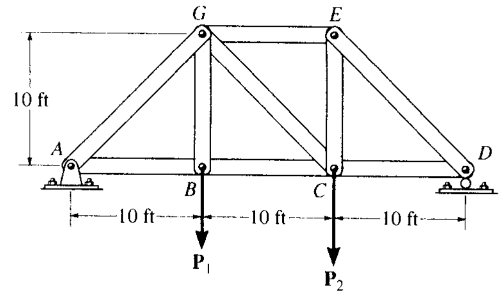
Joint C :

$+\uparrow \Sigma F_y = 0;$ $\quad F_{CG}\cos 45° + 666.7 - 1000 = 0$



$F_{CG} = 471$ lb (T) **Ans**

6-11. Determine the force in each member of the truss and state if the members are in tension or compression. Set $P_1 = 500$ lb, $P_2 = 1500$ lb.



Reactions at A and D :

$$A_x = 0$$

$$A_y = 833.33 \text{ lb}$$

$$D_y = 1166.67 \text{ lb}$$

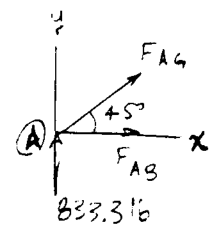
Joint A :

$\overset{+}{\rightarrow}\Sigma F_x = 0;\quad F_{AB} - F_{AG}\cos 45° = 0$

$+\uparrow \Sigma F_y = 0;\quad 833.33 - F_{AG}\sin 45° = 0$

$F_{AG} = 1178.51 = 1179 \text{ lb (C)}$ **Ans**

$F_{AB} = 833.33 = 833 \text{ lb (T)}$ **Ans**



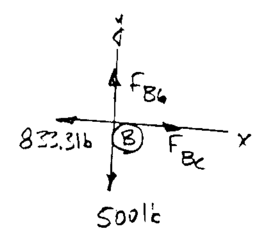
Joint B :

$\overset{+}{\rightarrow}\Sigma F_x = 0;\quad F_{BC} - 833 = 0$

$+\uparrow \Sigma F_y = 0;\quad F_{BG} - 500 = 0$

$F_{BC} = 833 \text{ lb (T)}$ **Ans**

$F_{BG} = 500 \text{ lb (T)}$ **Ans**



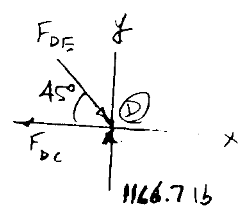
Joint D :

$\overset{+}{\rightarrow}\Sigma F_x = 0;\quad -F_{DC} + F_{DE}\cos 45° = 0$

$+\uparrow \Sigma F_y = 0;\quad 1166.67 - F_{DE}\sin 45° = 0$

$F_{DE} = 1649.96 = 1650 \text{ lb (C)}$ **Ans**

$F_{DC} = 1166.67 = 1167 \text{ lb (T)}$ **Ans**



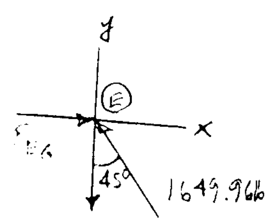
Joint E :

$\overset{+}{\rightarrow}\Sigma F_x = 0;\quad F_{EG} - 1649.96\sin 45° = 0$

$+\uparrow \Sigma F_y = 0;\quad -F_{EC} + 1649.96\cos 45° = 0$

$F_{EC} = 1166.67 = 1167 \text{ lb (T)}$ **Ans**

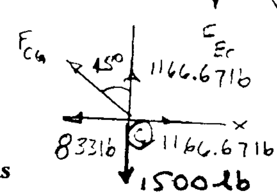
$F_{EG} = 1166.67 = 1167 \text{ lb (C)}$ **Ans**



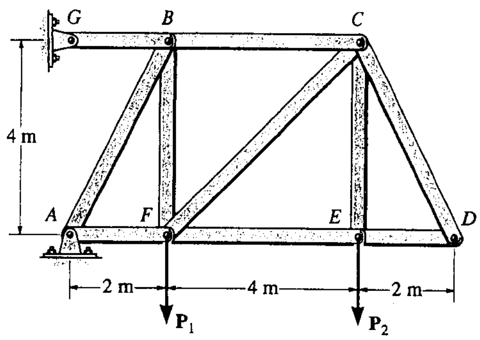
Joint C :

$+\uparrow \Sigma F_y = 0;\quad F_{CG}\cos 45° + 1166.67 - 1500 = 0$

$F_{CG} = 470.93 = 471 \text{ lb (T)}$ **Ans**



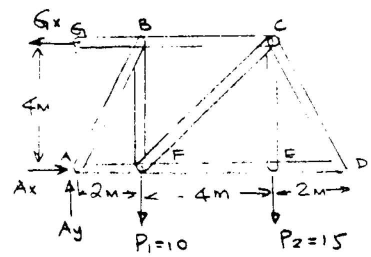
***6-12.** Determine the force in each member of the truss and state if the members are in tension or compression. Set $P_1 = 10$ kN, $P_2 = 15$ kN.



Probs. 6–12/13

$\curvearrowleft + \Sigma M_A = 0; \qquad G_x(4) - 10(2) - 15(6) = 0$

$G_x = 27.5$ kN



$\overset{+}{\rightarrow}\Sigma F_x = 0; \qquad A_x - 27.5 = 0$

$A_x = 27.5$ kN

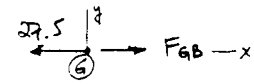
$+\uparrow \Sigma F_y = 0; \qquad A_y - 10 - 15 = 0$

$A_y = 25$ kN

Joint G :

$\overset{+}{\rightarrow}\Sigma F_x = 0; \qquad F_{GB} - 27.5 = 0$

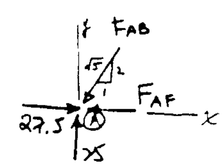
$F_{GB} = 27.5$ kN (T) **Ans**



Joint A :

$\overset{+}{\rightarrow}\Sigma F_x = 0; \qquad 27.5 - F_{AF} - \frac{1}{\sqrt{5}}(F_{AB}) = 0$

$+\uparrow \Sigma F_y = 0; \qquad 25 - F_{AB}(\frac{2}{\sqrt{5}}) = 0$



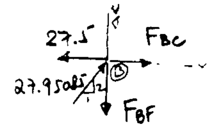
$F_{AF} = 15.0$ kN (C) **Ans**

$F_{AB} = 27.95 = 28.0$ kN (C) **Ans**

Joint B :

$\overset{+}{\rightarrow}\Sigma F_x = 0; \qquad 27.95(\frac{1}{\sqrt{5}}) + F_{BC} - 27.5 = 0$

$+\uparrow \Sigma F_y = 0; \qquad 27.95(\frac{2}{\sqrt{5}}) - F_{BF} = 0$



$F_{BF} = 24.99 = 25.0$ kN (T) **Ans**

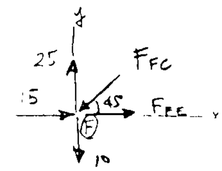
$F_{BC} = 15.0$ kN (T) **Ans**

6-12 cont'd

Joint F:

$\xrightarrow{+}\Sigma F_x = 0;\qquad 15 + F_{FE} - \frac{1}{\sqrt{2}}(F_{FC}) = 0$

$+\uparrow\Sigma F_y = 0;\qquad 25 - 10 - F_{FC}(\frac{1}{\sqrt{2}}) = 0$



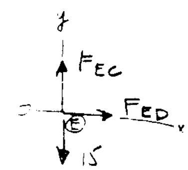
$F_{FC} = 21.21 = 21.2\text{ kN (C)}$ **Ans**

$F_{FE} = 0$ **Ans**

Joint E:

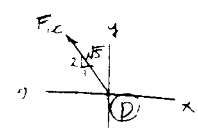
$\xrightarrow{+}\Sigma F_x = 0;\qquad F_{ED} = 0$ **Ans**

$+\uparrow\Sigma F_y = 0;\qquad F_{EC} - 15 = 0$



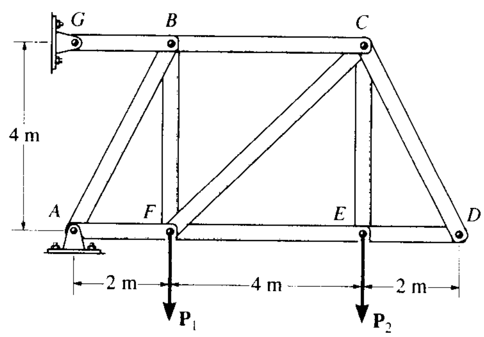
$F_{EC} = 15.0\text{ kN (T)}$ **Ans**

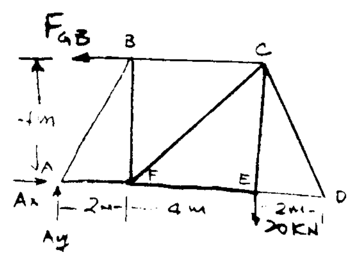
Joint D:



$\xrightarrow{+}\Sigma F_x = 0;\qquad F_{DC} = 0$ **Ans**

6-13. Determine the force in each member of the truss and state if the members are in tension or compression. Set $P_1 = 0$, $P_2 = 20$ kN.





$\curvearrowleft + \Sigma M_A = 0; \quad F_{GB}(4) - 20(6) = 0$

$F_{GB} = 30 \text{ kN (T)}$ **Ans**

$\xrightarrow{+} \Sigma F_x = 0; \quad A_x - 30 = 0$

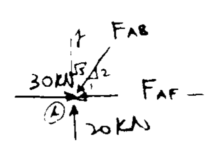
$A_x = 30 \text{ kN}$

$+\uparrow \Sigma F_y = 0; \quad A_y - 20 = 0$

$A_y = 20 \text{ kN}$

Joint A :

$\xrightarrow{+} \Sigma F_x = 0; \quad 30 - F_{AF} - \frac{1}{\sqrt{5}}(F_{AB}) = 0$



$+\uparrow \Sigma F_y = 0; \quad 20 - F_{AB}(\frac{2}{\sqrt{5}}) = 0$

$F_{AF} = 20 \text{ kN (C)}$ **Ans**

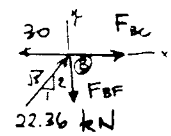
$F_{AB} = 22.36 = 22.4 \text{ kN (C)}$ **Ans**

6-13 cont'd

Joint B :

$\xrightarrow{+}\Sigma F_x = 0;$ $\quad 22.36(\frac{1}{\sqrt{5}}) + F_{BC} - 30 = 0$

$+\uparrow \Sigma F_y = 0;$ $\quad 22.36(\frac{2}{\sqrt{5}}) - F_{BF} = 0$

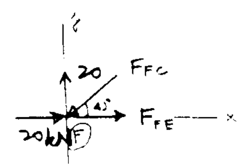


$F_{BF} = 20 \text{ kN (T)}$ **Ans**

$F_{BC} = 20 \text{ kN (T)}$ **Ans**

Joint F :

$\xrightarrow{+}\Sigma F_x = 0;$ $\quad 20 + F_{FE} - \frac{1}{\sqrt{2}}(F_{FC}) = 0$



$+\uparrow \Sigma F_y = 0;$ $\quad 20 - F_{FC}(\frac{1}{\sqrt{2}}) = 0$

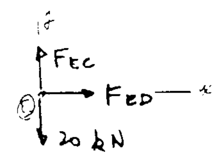
$F_{FC} = 28.28 = 28.3 \text{ kN (C)}$ **Ans**

$F_{FE} = 0$ **Ans**

Joint E :

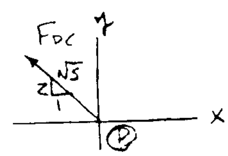
$\xrightarrow{+}\Sigma F_x = 0;$ $\quad F_{ED} - 0 = 0$

$+\uparrow \Sigma F_y = 0;$ $\quad F_{EC} - 20 = 0$



$F_{ED} = 0$ **Ans**

$F_{EC} = 20.0 \text{ kN (T)}$ **Ans**

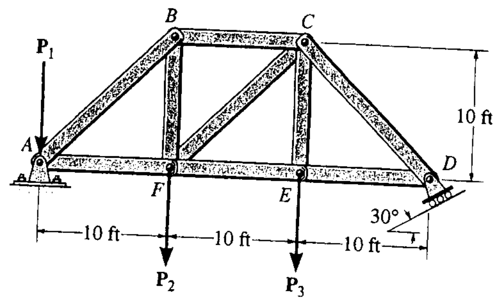


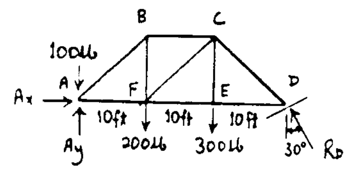
Joint D :

$\xrightarrow{+}\Sigma F_x = 0;$ $\quad \frac{1}{\sqrt{5}}(F_{DC}) - 0 = 0$

$F_{DC} = 0$ **Ans**

6-14. Determine the force in each member of the truss and state if the members are in tension or compression. Set $P_1 = 100$ lb, $P_2 = 200$ lb, $P_3 = 300$ lb.





$\curvearrowright + \Sigma M_A = 0;$ $200(10) + 300(20) - R_D \cos 30°(30) = 0$

$R_D = 307.9$ lb

$+\uparrow \Sigma F_y = 0;$ $A_y - 100 - 200 - 300 + 307.9 \cos 30° = 0$

$A_y = 333.4$ lb

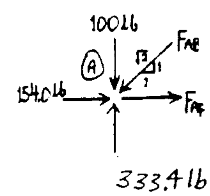
$\xrightarrow{+} \Sigma F_x = 0;$ $A_x - 307.9 \sin 30° = 0$

$A_x = 154.0$ lb

Joint A :

$+\uparrow \Sigma F_y = 0;$ $333.4 - 100 - \frac{1}{\sqrt{2}} F_{AB} = 0$

$F_{AB} = 330$ lb (C) **Ans**



$\xrightarrow{+} \Sigma F_x = 0;$ $154.0 + F_{AF} - \frac{1}{\sqrt{2}}(330) = 0$

$F_{AF} = 79.37 = 79.4$ lb (T) **Ans**

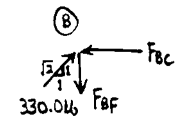
Con'd

6-14 cont'd

Joint B:

$+\uparrow \Sigma F_y = 0;$ $\quad \frac{1}{\sqrt{2}}(330) - F_{BF} = 0$

$F_{BF} = 233.3 = 233 \text{ lb (T)}$ **Ans**



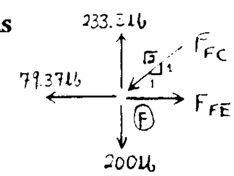
$\overset{+}{\rightarrow} \Sigma F_x = 0;$ $\quad \frac{1}{\sqrt{2}}(330) - F_{BC} = 0$

$F_{BC} = 233.3 = 233 \text{ lb (C)}$ **Ans**

Joint F:

$+\uparrow \Sigma F_y = 0;$ $\quad -\frac{1}{\sqrt{2}}F_{FC} - 200 + 233.3 = 0$

$F_{FC} = 47.14 = 47.1 \text{ lb (C)}$ **Ans**



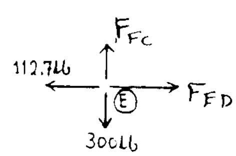
$\overset{+}{\rightarrow} \Sigma F_x = 0;$ $\quad F_{FE} - 79.37 - \frac{1}{\sqrt{2}}(47.14) = 0$

$F_{FE} = 112.7 = 113 \text{ lb (T)}$ **Ans**

Joint E:

$\overset{+}{\rightarrow} \Sigma F_x = 0;$ $\quad F_{EC} = 300 \text{ lb (T)}$ **Ans**

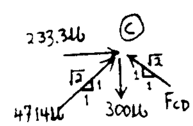
$+\uparrow \Sigma F_y = 0;$ $\quad F_{ED} = 112.7 = 113 \text{ lb (T)}$ **Ans**



Joint C:

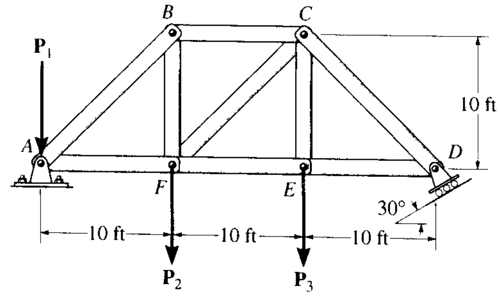
$\overset{+}{\rightarrow} \Sigma F_x = 0;$ $\quad \frac{1}{\sqrt{2}}(47.14) + 233.3 - \frac{1}{\sqrt{2}}F_{CD} = 0$

$F_{CD} = 377.1 = 377 \text{ lb (C)}$ **Ans**



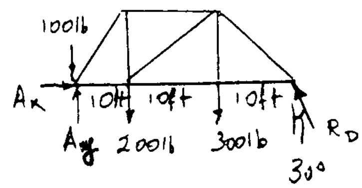
$+\uparrow \Sigma F_y = 0;$ $\quad \frac{1}{\sqrt{2}}(47.14) - 300 + \frac{1}{\sqrt{2}}(377.1) = 0$ Check!

6-15. Determine the force in each member of the truss and state if the members are in tension or compression. Set $P_1 = 400$ lb, $P_2 = 400$ lb, $P_3 = 0$.



$\circlearrowleft + \Sigma M_A = 0;$ $\quad -400(10) + R_D \cos 30°(30) = 0$

$R_D = 153.96$ lb



$+\uparrow \Sigma F_y = 0;$ $\quad A_y - 400 - 400 + 153.96 \cos 30° = 0$

$A_y = 666.67$ lb

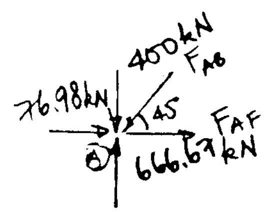
$\overset{+}{\rightarrow} \Sigma F_x = 0;$ $\quad A_x - 153.96 \sin 30° = 0$

$A_x = 76.98$ lb

Joint A :

$+\uparrow \Sigma F_y = 0;$ $\quad 666.67 - 400 - \frac{1}{\sqrt{2}} F_{AB} = 0$

$F_{AB} = 377.12 = 377$ lb (C) **Ans**

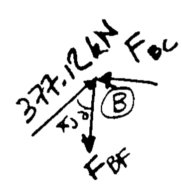


$\overset{+}{\rightarrow} \Sigma F_x = 0;$ $\quad 76.98 + F_{AF} - \frac{1}{\sqrt{2}}(377.12) = 0$

$F_{AF} = 189.68 = 190$ lb (T) **Ans**

Joint B :

$+\uparrow \Sigma F_y = 0;$ $\quad \frac{1}{\sqrt{2}}(377.12) - F_{BF} = 0$



$F_{BF} = 266.67 = 267$ lb (T) **Ans**

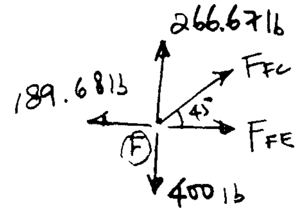
$\overset{+}{\rightarrow} \Sigma F_x = 0;$ $\quad \frac{1}{\sqrt{2}}(377.12) - F_{BC} = 0$

$F_{BC} = 266.67 = 267$ lb (C) **Ans**

Con'd

6-15 cont'd

Joint F:



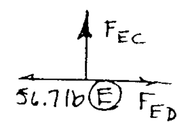
$+\uparrow \Sigma F_y = 0;\quad \frac{1}{\sqrt{2}} F_{FC} - 400 + 266.67 = 0$

$F_{FC} = 188.56 = 189 \text{ lb (T)}$ **Ans**

$\xrightarrow{+} \Sigma F_x = 0;\quad F_{FE} - 190 + \frac{1}{\sqrt{2}}(188.56) = 0$

$F_{FE} = 56.68 = 56.7 \text{ lb (T)}$ **Ans**

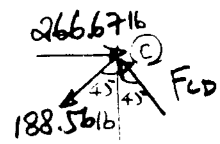
Joint E:



$\xrightarrow{+} \Sigma F_x = 0;\quad F_{ED} = 56.7 \text{ lb (T)}$ **Ans**

$+\uparrow \Sigma F_y = 0;\quad F_{EC} = 0$ **Ans**

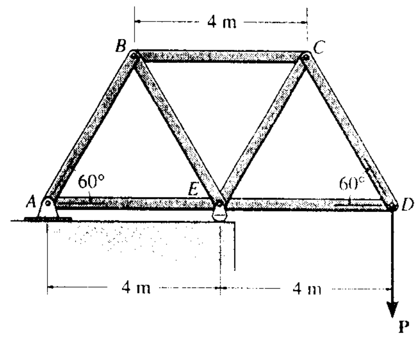
Joint C:



$\xrightarrow{+} \Sigma F_x = 0;\quad -\frac{1}{\sqrt{2}}(188.56) + 266.67 - \frac{1}{\sqrt{2}} F_{CD} = 0$

$F_{CD} = 188.57 = 189 \text{ lb (C)}$ **Ans**

***6-16.** Determine the force in each member of the truss. State whether the members are in tension or compression. Set $P = 8$ kN.



Method of Joints : In this case, the support reactions are not required for determining the member forces.

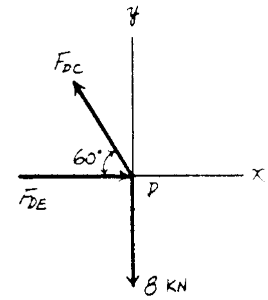
Joint *D*

$+\uparrow \Sigma F_y = 0; \quad F_{DC} \sin 60° - 8 = 0$

$F_{DC} = 9.238 \text{ kN (T)} = 9.24 \text{ kN (T)}$ **Ans**

$\overset{+}{\rightarrow} \Sigma F_x = 0; \quad F_{DE} - 9.238 \cos 60° = 0$

$F_{DE} = 4.619 \text{ kN (C)} = 4.62 \text{ kN (C)}$ **Ans**



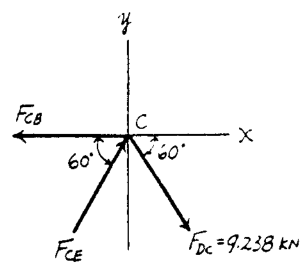
Joint *C*

$+\uparrow \Sigma F_y = 0; \quad F_{CE} \sin 60° - 9.238 \sin 60° = 0$

$F_{CE} = 9.238 \text{ kN (C)} = 9.24 \text{ kN (C)}$ **Ans**

$\overset{+}{\rightarrow} \Sigma F_x = 0; \quad 2(9.238 \cos 60°) - F_{CB} = 0$

$F_{CB} = 9.238 \text{ kN (T)} = 9.24 \text{ kN (T)}$ **Ans**



Joint *B*

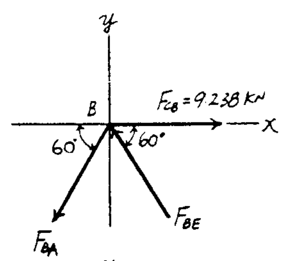
$+\uparrow \Sigma F_y = 0; \quad F_{BE} \sin 60° - F_{BA} \sin 60° = 0$

$F_{BE} = F_{BA} = F$

$\overset{+}{\rightarrow} \Sigma F_x = 0; \quad 9.238 - 2F \cos 60° = 0$

$F = 9.238 \text{ kN}$

Thus, $\quad F_{BE} = 9.24 \text{ kN (C)} \quad F_{BA} = 9.24 \text{ kN (T)}$ **Ans**



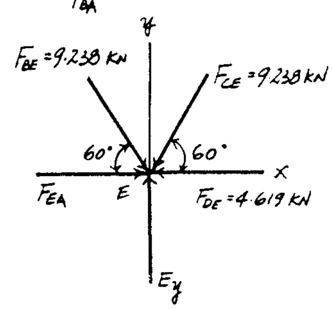
Joint *E*

$+\uparrow \Sigma F_y = 0; \quad E_y - 2(9.238 \sin 60°) = 0 \quad E_y = 16.0 \text{ kN}$

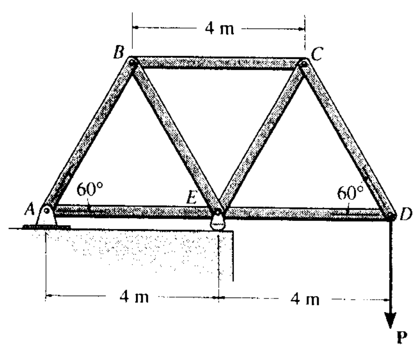
$\overset{+}{\rightarrow} \Sigma F_x = 0; \quad F_{EA} + 9.238 \cos 60° - 9.238 \cos 60° + 4.619 = 0$

$F_{EA} = 4.62 \text{ kN (C)}$ **Ans**

Note : The support reactions A_x and A_y can be determined by analysing Joint *A* using the results obtained above.



6-17. If the maximum force that any member can support is 8 kN in tension and 6 kN in compression, determine the maximum force P that can be supported at joint D.

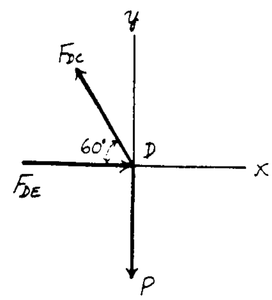


Method of Joints : In this case, the support reactions are not required for determining the member forces.

Joint *D*

$+\uparrow \Sigma F_y = 0;\quad F_{DC}\sin 60° - P = 0 \quad F_{DC} = 1.1547P\ \text{(T)}$

$\xrightarrow{+} \Sigma F_x = 0;\quad F_{DE} - 1.1547P\cos 60° = 0 \quad F_{DE} = 0.57735P\ \text{(C)}$

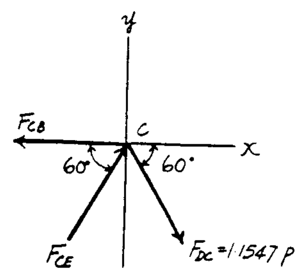


Joint *C*

$+\uparrow \Sigma F_y = 0;\quad F_{CE}\sin 60° - 1.1547P\sin 60° = 0$

$F_{CE} = 1.1547P\ \text{(C)}$

$\xrightarrow{+} \Sigma F_x = 0;\quad 2(1.1547P\cos 60°) - F_{CB} = 0 \quad F_{CB} = 1.1547P\ \text{(T)}$

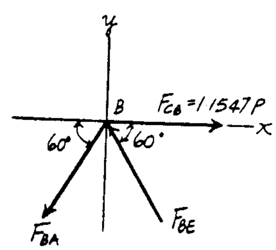


Joint *B*

$+\uparrow \Sigma F_y = 0;\quad F_{BE}\sin 60° - F_{BA}\sin 60° = 0 \quad F_{BE} = F_{BA} = F$

$\xrightarrow{+} \Sigma F_x = 0;\quad 1.1547P - 2F\cos 60° = 0 \quad F = 1.1547P$

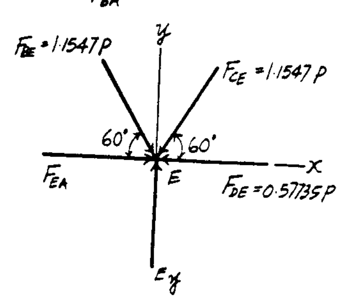
Thus, $\quad F_{BE} = 1.1547P\ \text{(C)} \quad F_{BA} = 1.1547P\ \text{(T)}$



Joint *E*

$\xrightarrow{+} \Sigma F_x = 0;\quad F_{EA} + 1.1547P\cos 60° - 1.1547P\cos 60° + 0.57735P = 0$

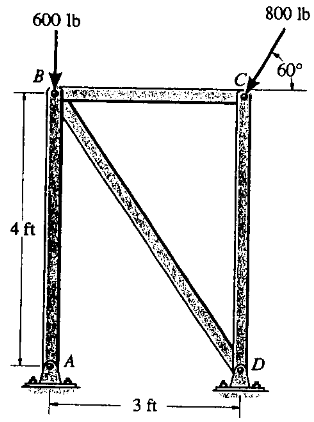
$F_{EA} = 0.57735P\ \text{(C)}$



From the above analysis, the maximum compression and tension in the truss member is $1.1547P$. For this case, compression controls which requires

$$1.1547P = 6$$
$$P = 5.20\ \text{kN} \qquad \textbf{Ans}$$

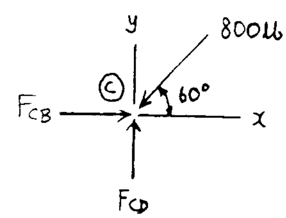
6-18. Determine the force in each member of the truss and state if the members are in tension or compression. *Hint:* The horizontal force component at A must be zero. Why?



Joint C :

$\xrightarrow{+}\Sigma F_x = 0;$ $F_{CB} - 800\cos 60° = 0$

$F_{CB} = 400 \text{ lb (C)}$ **Ans**



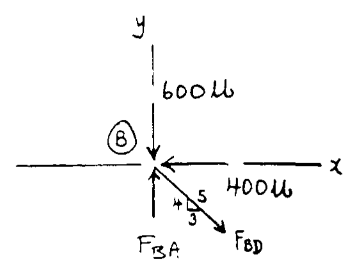
$+\uparrow\Sigma F_y = 0;$ $F_{CD} - 800\sin 60° = 0$

$F_{CD} = 693 \text{ lb (C)}$ **Ans**

Joint B :

$\xrightarrow{+}\Sigma F_x = 0;$ $\frac{3}{5}F_{BD} - 400 = 0$

$F_{BD} = 666.7 = 667 \text{ lb (T)}$ **Ans**

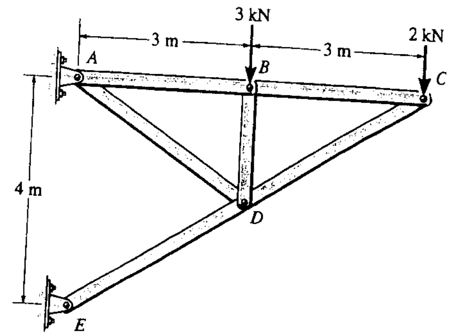


$+\uparrow\Sigma F_y = 0;$ $F_{BA} - \frac{4}{5}(666.7) - 600 = 0$

$F_{BA} = 1133 \text{ lb} = 1.13 \text{ kip (C)}$ **Ans**

Member AB is a two - force member and exerts only a vertical force along AB at A.

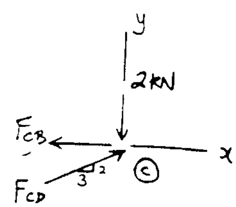
6-19. Determine the force in each member of the truss and state if the members are in tension or compression. *Hint:* The resultant force at the pin E acts along member ED. Why?



Joint C:

$+\uparrow \Sigma F_y = 0;\qquad \frac{2}{\sqrt{13}}F_{CD} - 2 = 0$

$F_{CD} = 3.606 = 3.61\ \text{kN (C)}$ **Ans**



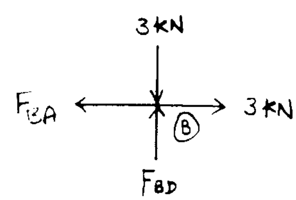
$\overset{+}{\rightarrow}\Sigma F_x = 0;\qquad -F_{CB} + 3.606\left(\frac{3}{\sqrt{13}}\right) = 0$

$F_{CB} = 3\ \text{kN (T)}$ **Ans**

Joint B:

$\overset{+}{\rightarrow}\Sigma F_x = 0;\qquad F_{BA} = 3\ \text{kN (T)}$ **Ans**

$+\uparrow\Sigma F_y = 0;\qquad F_{BD} = 3\ \text{kN (C)}$ **Ans**



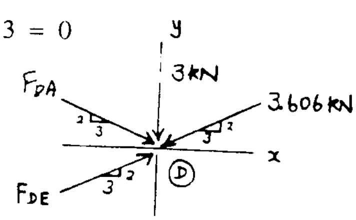
Joint D:

$\overset{+}{\rightarrow}\Sigma F_x = 0;\qquad \frac{3}{\sqrt{13}}F_{DE} - \frac{3}{\sqrt{13}}(3.606) + \frac{3}{\sqrt{13}}F_{DA} = 0$

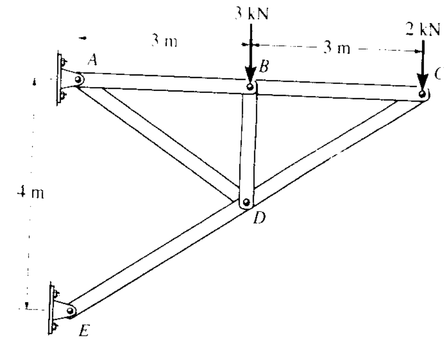
$+\uparrow\Sigma F_y = 0;\qquad \frac{2}{\sqrt{13}}(F_{DE}) - \frac{2}{\sqrt{13}}(F_{DA}) - \frac{2}{\sqrt{13}}(3.606) - 3 = 0$

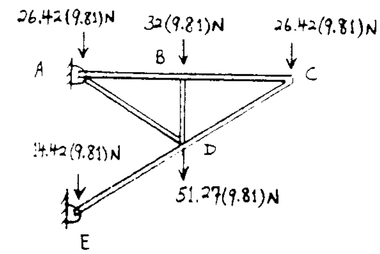
$F_{DA} = 2.70\ \text{kN (T)}$ **Ans**

$F_{DE} = 6.31\ \text{kN (C)}$ **Ans**



***6-20.** Each member of the truss is uniform and has a mass of 8 kg/m. Remove the external loads of 3 kN and 2 kN and determine the approximate force in each member due to the weight of the truss. State if the members are in tension or compression. Solve the problem by *assuming* the weight of each member can be represented as a vertical force, half of which is applied at each end of the member.

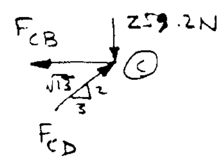




Joint C:

$+\uparrow \Sigma F_y = 0;\qquad \frac{2}{\sqrt{13}}F_{CD} - 259.2 = 0$

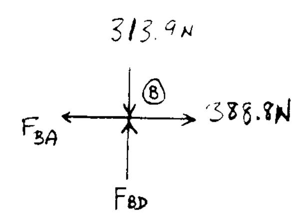
$F_{CD} = 467.3 = 467 \text{ N (C)}$ **Ans**



$\xrightarrow{+}\Sigma F_x = 0;\qquad -F_{CB} + 467.3(\frac{3}{\sqrt{13}}) = 0$

$F_{CB} = 388.8 = 389 \text{ N (T)}$ **Ans**

Joint B:



$\xrightarrow{+}\Sigma F_x = 0;\qquad F_{BA} = 388.8 = 389 \text{ N (T)}$ **Ans**

$+\uparrow\Sigma F_y = 0;\qquad F_{BD} = 313.9 = 314 \text{ N (C)}$ **Ans**

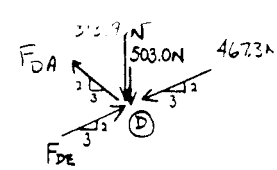
Joint D:

$\xrightarrow{+}\Sigma F_x = 0;\qquad \frac{3}{\sqrt{13}}F_{DE} - \frac{3}{\sqrt{13}}(467.3) - \frac{3}{\sqrt{13}}F_{DA} = 0$

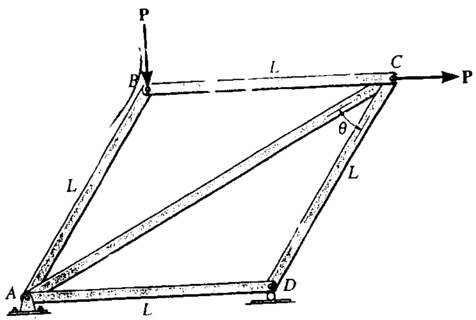
$+\uparrow\Sigma F_y = 0;\qquad \frac{2}{\sqrt{13}}(F_{DE}) + \frac{2}{\sqrt{13}}(F_{DA}) - \frac{2}{\sqrt{13}}(467.3) - 313.9 - 503.0 = 0$

$F_{DE} = 1203 = 1.20 \text{ kN (C)}$ **Ans**

$F_{DA} = 736 \text{ N (T)}$ **Ans**



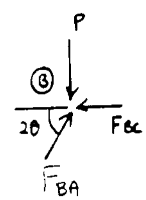
6-21. Determine the force in each member of the truss in terms of the external loading and state if the members are in tension or compression.



Joint B :

$+\uparrow \Sigma F_y = 0;$ $\qquad F_{BA}\sin 2\theta - P = 0$

$F_{BA} = P\csc 2\theta$ (C) **Ans**



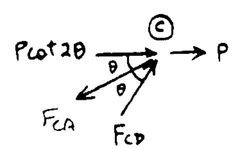
$\xrightarrow{+}\Sigma F_x = 0;$ $\qquad P\csc 2\theta(\cos 2\theta) - F_{BC} = 0$

$F_{BC} = P\cot 2\theta$ (C) **Ans**

Joint C :

$\xrightarrow{+}\Sigma F_x = 0;$ $\qquad P\cot 2\theta + P + F_{CD}\cos 2\theta - F_{CA}\cos\theta = 0$

$+\uparrow \Sigma F_y = 0;$ $\qquad F_{CD}\sin 2\theta - F_{CA}\sin\theta = 0$



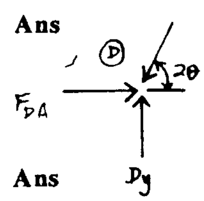
$$F_{CA} = \frac{\cot 2\theta + 1}{\cos\theta - \sin\theta\cot 2\theta}P$$

$F_{CA} = (\cot\theta\cos\theta - \sin\theta + 2\cos\theta)P$ (T) **Ans**

(cot2θ+1)P

$F_{CD} = (\cot 2\theta + 1)P$ (C) **Ans**

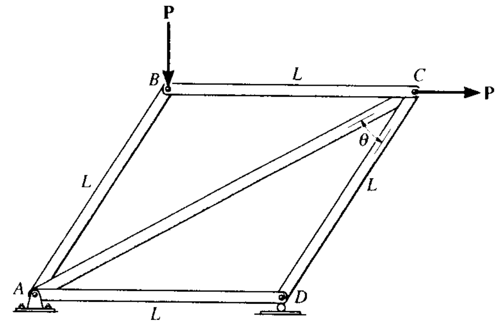
Joint D :



$\xrightarrow{+}\Sigma F_x = 0;$ $\qquad F_{DA} - (\cot 2\theta + 1)(\cos 2\theta)P = 0$

$F_{DA} = (\cot 2\theta + 1)(\cos 2\theta)(P)$ (C) **Ans**

6-22. The maximum allowable tensile force in the members of the truss is $(F_t)_{max} = 2$ kN, and the maximum allowable compressive force is $(F_c)_{max} = 1.2$ kN. Determine the maximum magnitude P of the two loads that can be applied to the truss. Take $L = 2$ m and $\theta = 30°$.



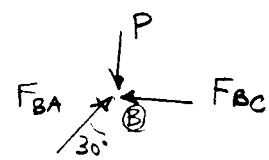
$$(T_t)_{max} = 2 \text{ kN}$$

$$(F_C)_{max} = 1.2 \text{ kN}$$

Joint B :

$$+\uparrow \Sigma F_y = 0; \quad F_{BA}\cos 30° - P = 0$$

$$F_{BA} = \frac{P}{\cos 30°} = 1.1547\,P\,(C)$$



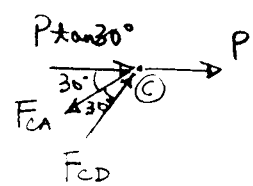
$$\overset{+}{\rightarrow} \Sigma F_x = 0; \quad F_{AB}\sin 30° - F_{BC} = 0$$

$$F_{BC} = P\tan 30° = 0.57735\,P\,(C)$$

Joint C :

$$+\uparrow \Sigma F_y = 0; \quad -F_{CA}\cos 30° + F_{CD}\sin 60° = 0$$

$$F_{CA} = F_{CD}\left(\frac{\sin 60°}{\sin 30°}\right) = 1.732\,F_{CD}$$



$$\overset{+}{\rightarrow} \Sigma F_x = 0; \quad P\tan 30° + P + F_{CD}\cos 60° - F_{CA}\cos 30° = 0$$

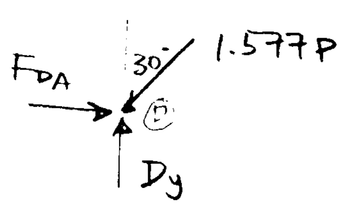
$$F_{CD} = \left(\frac{\tan 30° + 1}{\sqrt{3}\cos 30° - \cos 60°}\right)P = 1.577\,P\,(C)$$

$$F_{CA} = 2.732\,P\,(T)$$

Joint D :

$$\overset{+}{\rightarrow} \Sigma F_x = 0; \quad F_{DA} - 1.577\,P\sin 30° = 0$$

$$F_{DA} = 0.7887\,P\,(C)$$



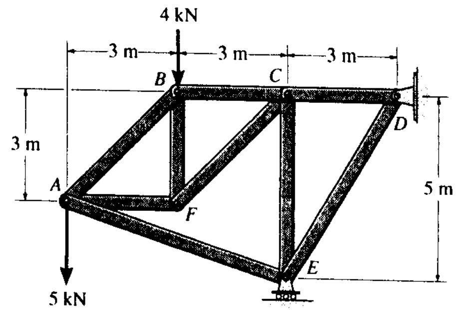
1) Assume $F_{CA} = 2 \text{ kN} = 2.732\,P$

$$P = 732.06 \text{ N}$$

$$F_{CD} = 1.577(732.06) = 1154.5 \text{ N} < (F_c)_{max} = 1200 \text{ N} \qquad \textbf{(O.K!)}$$

Thus, $\quad P_{max} = 732$ N $\qquad$ **Ans**

6-23. Determine the force in each member of the truss and state if the members are in tension or compression.

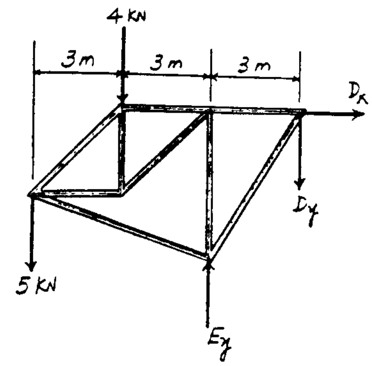


Support Reactions :

$\circlearrowleft + \Sigma M_D = 0; \quad 4(6) + 5(9) - E_y(3) = 0 \quad E_y = 23.0 \text{ kN}$

$+\uparrow \Sigma F_y = 0; \quad 23.0 - 4 - 5 - D_y = 0 \quad D_y = 14.0 \text{ kN}$

$\xrightarrow{+} \Sigma F_x = 0 \quad D_x = 0$



Method of Joints :

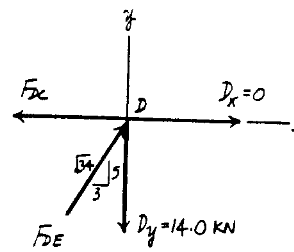
Joint *D*

$+\uparrow \Sigma F_y = 0; \quad F_{DE}\left(\frac{5}{\sqrt{34}}\right) - 14.0 = 0$

$F_{DE} = 16.33 \text{ kN (C)} = 16.3 \text{ kN (C)}$ **Ans**

$\xrightarrow{+} \Sigma F_x = 0; \quad 16.33\left(\frac{3}{\sqrt{34}}\right) - F_{DC} = 0$

$F_{DC} = 8.40 \text{ kN (T)}$ **Ans**



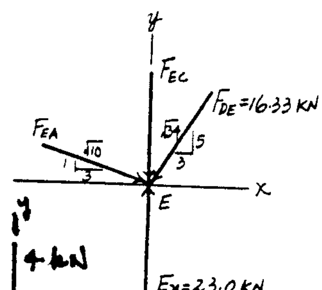
Joint *E*

$\xrightarrow{+} \Sigma F_x = 0; \quad F_{EA}\left(\frac{3}{\sqrt{10}}\right) - 16.33\left(\frac{3}{\sqrt{34}}\right) = 0$

$F_{EA} = 8.854 \text{ kN (C)} = 8.85 \text{ kN (C)}$ **Ans**

$+\uparrow \Sigma F_y = 0; \quad 23.0 - 16.33\left(\frac{5}{\sqrt{34}}\right) - 8.854\left(\frac{1}{\sqrt{10}}\right) - F_{EC} = 0$

$F_{EC} = 6.20 \text{ kN (C)}$ **Ans**



Joint *C*

$+\uparrow \Sigma F_y = 0; \quad 6.20 - F_{CF}\sin 45° = 0$

$F_{CF} = 8.768 \text{ kN (T)} = 8.77 \text{ kN (T)}$ **Ans**

$\xrightarrow{+} \Sigma F_x = 0; \quad 8.40 - 8.768\cos 45° - F_{CB} = 0$

$F_{CB} = 2.20 \text{ kN (T)}$ **Ans**

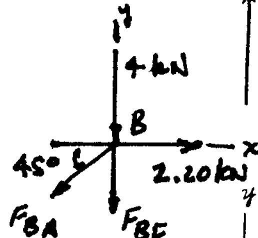
Joint *B*

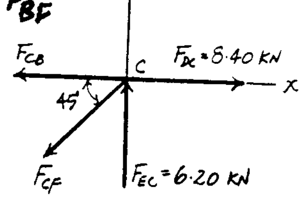
$\xrightarrow{+} \Sigma F_x = 0; \quad 2.20 - F_{BA}\cos 45° = 0$

$F_{BA} = 3.111 \text{ kN (T)} = 3.11 \text{ kN (T)}$ **Ans**

$+\uparrow \Sigma F_y = 0; \quad F_{BF} - 4 - 3.111\sin 45° = 0$

$F_{BF} = 6.20 \text{ kN (C)}$ **Ans**



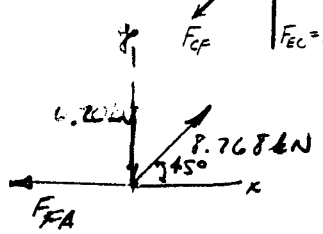


Joint *F*

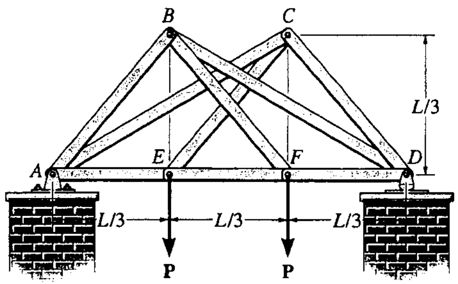
$+\uparrow \Sigma F_y = 0; \quad 8.768\sin 45° - 6.20 = 0$ ***(Check!)***

$\xrightarrow{+} \Sigma F_x = 0; \quad 8.768\cos 45° - F_{FA} = 0$

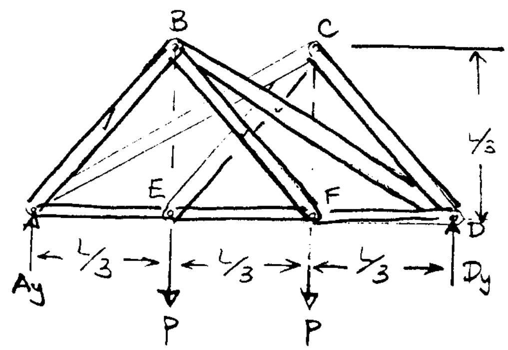
$F_{FA} = 6.20 \text{ kN (T)}$ **Ans**



***6-24.** Determine the force in each member of the double scissors truss in terms of the load P and state if the members are in tension or compression.



Prob. 6–24



$$\circlearrowleft + \Sigma M_A = 0; \quad P(\frac{L}{3}) + P(\frac{2L}{3}) - (D_y)(L) = 0$$

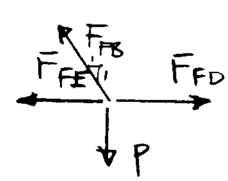
$$D_y = P$$

$$+\uparrow \Sigma F_y = 0; \quad A_y = P$$

Joint F:

$$+\uparrow \Sigma F_y = 0; \quad F_{FB}(\frac{1}{\sqrt{2}}) - P = 0$$

$$F_{FB} = \sqrt{2}P = 1.41P\,(\mathrm{T})$$



$$\overset{+}{\rightarrow} \Sigma F_x = 0; \quad F_{FD} - F_{FE} - F_{FB}(\frac{1}{\sqrt{2}}) = 0$$

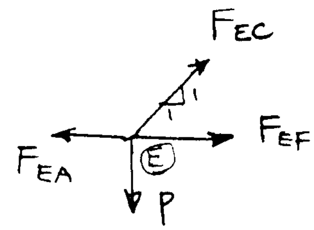
$$F_{FD} - F_{FE} = P \qquad (1)$$

Con'd

6-24 cont'd

Joint E :

$+\uparrow \Sigma F_y = 0; \quad F_{EC}(\frac{1}{\sqrt{2}}) - P = 0$



$F_{EC} = \sqrt{2}P = 1.41P\,(T)$

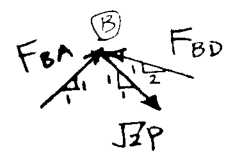
$\xrightarrow{+} \Sigma F_x = 0; \quad F_{EF} - F_{EA} + 1.41P(\frac{1}{\sqrt{2}}) = 0$

$F_{EA} - F_{EF} = P \qquad (2)$

Joint B :

$+\uparrow \Sigma F_y = 0; \quad F_{BA}(\frac{1}{\sqrt{2}}) + F_{BD}(\frac{1}{\sqrt{5}}) - (\sqrt{2}P)(\frac{1}{\sqrt{2}}) = 0$

$\frac{1}{\sqrt{2}}F_{BA} + \frac{1}{\sqrt{5}}F_{BD} = P$



$\xrightarrow{+} \Sigma F_x = 0; \quad F_{BA}(\frac{1}{\sqrt{2}}) + \sqrt{2}P(\frac{1}{\sqrt{2}}) - F_{BD}(\frac{2}{\sqrt{5}}) = 0$

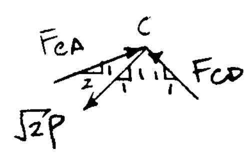
$\frac{1}{\sqrt{2}}F_{BA} - \frac{2}{\sqrt{5}}F_{BD} = -P$

$F_{BD} = \frac{2\sqrt{5}}{3}P = 1.4907P = 1.49P\,(C)$

$F_{BA} = \frac{\sqrt{2}}{3}P = 0.4714P = 0.471P\,(C)$

Joint C :

$+\uparrow \Sigma F_y = 0; \quad F_{CA}(\frac{1}{\sqrt{5}}) + F_{CD}(\frac{1}{\sqrt{2}}) - (\sqrt{2}P)(\frac{1}{\sqrt{2}}) = 0$



$\frac{1}{\sqrt{5}}F_{CA} + \frac{1}{\sqrt{2}}F_{CD} = P$

Con'd

6-24 cont'd

$$\xrightarrow{+} \Sigma F_x = 0; \quad F_{CA}\left(\frac{2}{\sqrt{5}}\right) - \sqrt{2}P\left(\frac{1}{\sqrt{2}}\right) - F_{CD}\left(\frac{1}{\sqrt{2}}\right) = 0$$

$$\frac{2}{\sqrt{5}}F_{CA} - \frac{1}{\sqrt{2}}F_{CD} = P$$

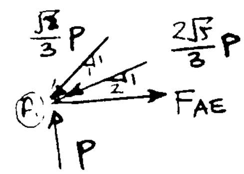
$$F_{CA} = \frac{2\sqrt{5}}{3}P = 1.4907P = 1.49P\,(C)$$

$$F_{CD} = \frac{\sqrt{2}}{3}P = 0.4714P = 0.471P\,(C)$$

Joint A :

$$\xrightarrow{+} \Sigma F_x = 0; \quad F_{AE} - \frac{\sqrt{2}}{3}P\left(\frac{1}{\sqrt{2}}\right) - \frac{2\sqrt{5}}{3}P\left(\frac{2}{\sqrt{5}}\right) = 0$$

$$F_{AE} = \frac{5}{3}P = 1.67\,P\,(T)$$



From Eqs. (1) and (2) :

$F_{EF} = 0.667\,P\,(T)$ **Ans**

$F_{FD} = 1.67\,P\,(T)$ **Ans**

$F_{AB} = 0.471\,P\,(C)$ **Ans**

$F_{AE} = 1.67\,P\,(T)$ **Ans**

$F_{AC} = 1.49P\,(C)$ **Ans**

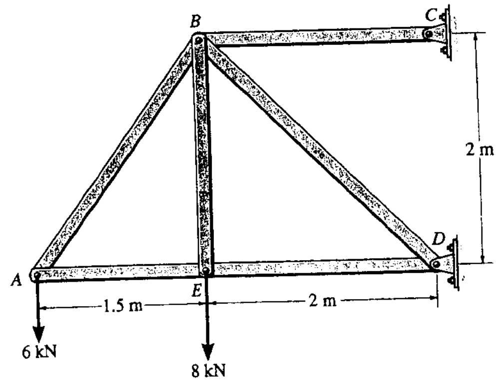
$F_{BF} = 1.41\,P\,(T)$ **Ans**

$F_{BD} = 1.49\,P\,(C)$ **Ans**

$F_{EC} = 1.41\,P\,(T)$ **Ans**

$F_{CD} = 0.471\,P\,(C)$ **Ans**

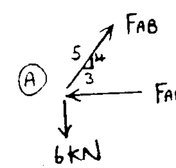
6-25. Determine the force in each member of the truss and state if the members are in tension or compression. *Hint:* The vertical component of force at C must equal zero. Why?



Joint A :

$+\uparrow \Sigma F_y = 0;\qquad \frac{4}{5}F_{AB} - 6 = 0$

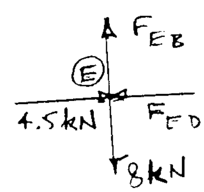
$F_{AB} = 7.5$ kN (T) **Ans**



$\xrightarrow{+} \Sigma F_x = 0;\qquad -F_{AE} + 7.5(\frac{3}{5}) = 0$

$F_{AE} = 4.5$ kN (C) **Ans**

Joint E:

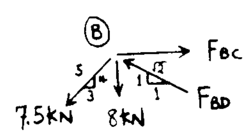


$\xrightarrow{+} \Sigma F_x = 0;\qquad F_{ED} = 4.5$ kN (C) **Ans**

$+\uparrow \Sigma F_y = 0;\qquad F_{EB} = 8$ kN (T) **Ans**

Joint B :

$+\uparrow \Sigma F_y = 0;\qquad \frac{1}{\sqrt{2}}(F_{BD}) - 8 - \frac{4}{5}(7.5) = 0$



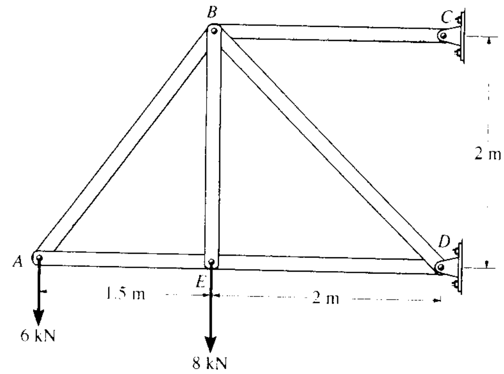
$F_{BD} = 19.8$ kN (C) **Ans**

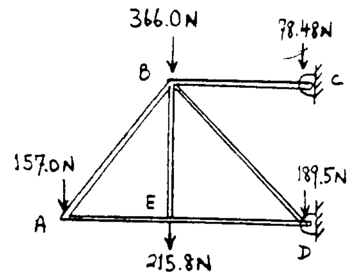
$\xrightarrow{+} \Sigma F_x = 0;\qquad F_{BC} - \frac{3}{5}(7.5) - \frac{1}{\sqrt{2}}(19.8) = 0$

$F_{BC} = 18.5$ kN (T) **Ans**

C_y is zero because BC is a two - force member.

6-26. Each member of the truss is uniform and has a mass of 8 kg/m. Remove the external loads of 6 kN and 8 kN and determine the approximate force in each member due to the weight of the truss. State if the members are in tension or compression. Solve the problem by *assuming* the weight of each member can be represented as a vertical force, half of which is applied at each end of the member.



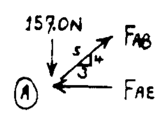


Joint A :

$+\uparrow\Sigma F_y = 0;$ $\quad \frac{4}{5}F_{AB} - 157.0 = 0$

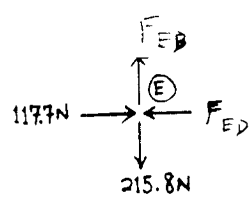
$F_{AB} = 196.2 = 196 \text{ N (T)}$ **Ans**

$\overset{+}{\rightarrow}\Sigma F_x = 0;$ $\quad -F_{AE} + 196.2(\frac{3}{5}) = 0$



$F_{AE} = 117.7 = 118 \text{ N (C)}$ **Ans**

Joint E :

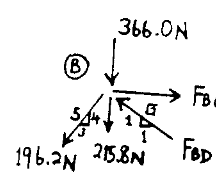


$\overset{+}{\rightarrow}\Sigma F_x = 0;$ $\quad F_{ED} = 117.7 = 118 \text{ N (C)}$ **Ans**

$+\uparrow\Sigma F_y = 0;$ $\quad F_{EB} = 215.8 = 216 \text{ N (T)}$ **Ans**

Joint B :

$+\uparrow\Sigma F_y = 0;$ $\quad \frac{1}{\sqrt{2}}(F_{BD}) - 366.0 - 215.8 - \frac{4}{5}(196.2) = 0$

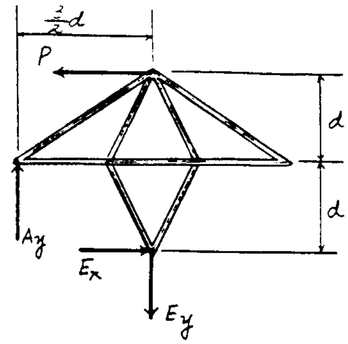


$F_{BD} = 1045 = 1.04 \text{ kN (C)}$ **Ans**

$\overset{+}{\rightarrow}\Sigma F_x = 0;$ $\quad F_{BC} - \frac{3}{5}(196.2) - \frac{1}{\sqrt{2}}(1045) = 0$

$F_{BC} = 857 \text{ N (T)}$ **Ans**

6-27. Determine the force in each member of the truss in terms of the load P, and indicate whether the members are in tension or compression.



Support Reactions :

$$\curvearrowleft + \Sigma M_E = 0; \quad P(2d) - A_y\left(\frac{3}{2}d\right) = 0 \quad A_y = \frac{4}{3}P$$

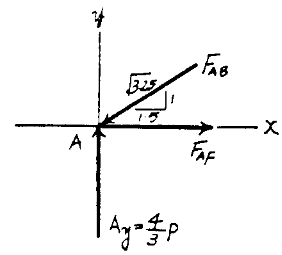
$$+\uparrow \Sigma F_y = 0; \quad \frac{4}{3}P - E_y = 0 \quad E_y = \frac{4}{3}P$$

$$\xrightarrow{+} \Sigma F_x = 0 \quad E_x - P = 0 \quad E_x = P$$

Method of Joints : By inspection of joint C, members CB and CD are zero force member. Hence

$$F_{CB} = F_{CD} = 0 \qquad \textbf{Ans}$$

Joint A



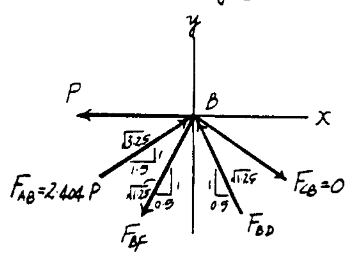
$$+\uparrow \Sigma F_y = 0; \quad F_{AB}\left(\frac{1}{\sqrt{3.25}}\right) - \frac{4}{3}P = 0$$

$$F_{AB} = 2.404P \text{ (C)} = 2.40P \text{ (C)} \qquad \textbf{Ans}$$

$$\xrightarrow{+} \Sigma F_x = 0; \quad F_{AF} - 2.404P\left(\frac{1.5}{\sqrt{3.25}}\right) = 0$$

$$F_{AF} = 2.00P \text{ (T)} \qquad \textbf{Ans}$$

Joint B



$$\xrightarrow{+} \Sigma F_x = 0; \quad 2.404P\left(\frac{1.5}{\sqrt{3.25}}\right) - P$$

$$- F_{BF}\left(\frac{0.5}{\sqrt{1.25}}\right) - F_{BD}\left(\frac{0.5}{\sqrt{1.25}}\right) = 0$$

$$1.00P - 0.4472F_{BF} - 0.4472F_{BD} = 0 \qquad [1]$$

$$+\uparrow \Sigma F_y = 0; \quad 2.404P\left(\frac{1}{\sqrt{3.25}}\right) + F_{BD}\left(\frac{1}{\sqrt{1.25}}\right) - F_{BF}\left(\frac{1}{\sqrt{1.25}}\right) = 0$$

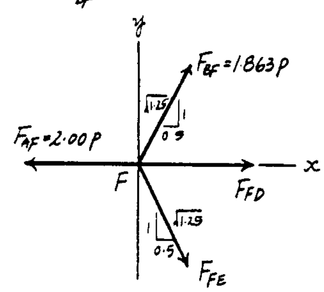
$$1.333P + 0.8944F_{BD} - 0.8944F_{BF} = 0 \qquad [2]$$

Solving Eqs.[1] and [2] yield,

$$F_{BF} = 1.863P\text{(T)} = 1.86P\text{(T)} \qquad \textbf{Ans}$$

$$F_{BD} = 0.3727P\text{(C)} = 0.373P\text{(C)} \qquad \textbf{Ans}$$

Joint F



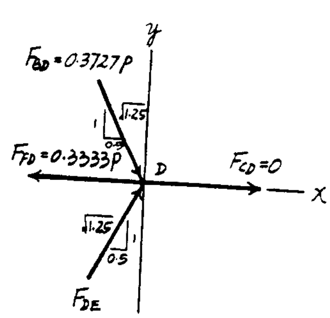
$$+\uparrow \Sigma F_y = 0; \quad 1.863P\left(\frac{1}{\sqrt{1.25}}\right) - F_{FE}\left(\frac{1}{\sqrt{1.25}}\right) = 0$$

$$F_{FE} = 1.863P\text{(T)} = 1.86P\text{(T)} \qquad \textbf{Ans}$$

$$\xrightarrow{+} \Sigma F_x = 0; \quad F_{FD} + 2\left[1.863P\left(\frac{0.5}{\sqrt{1.25}}\right)\right] - 2.00P = 0$$

$$F_{FD} = 0.3333P\text{(T)} = 0.333P\text{ (T)} \qquad \textbf{Ans}$$

Joint D

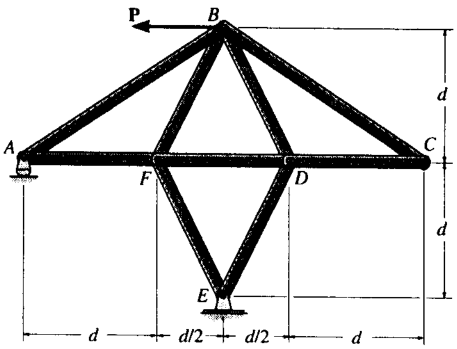


$$+\uparrow \Sigma F_y = 0; \quad F_{DE}\left(\frac{1}{\sqrt{1.25}}\right) - 0.3727P\left(\frac{1}{\sqrt{1.25}}\right) = 0$$

$$F_{DE} = 0.3727P \text{ (C)} = 0.373P \text{ (C)} \qquad \textbf{Ans}$$

$$\xrightarrow{+} \Sigma F_x = 0; \quad 2\left[0.3727P\left(\frac{0.5}{\sqrt{1.25}}\right)\right] - 0.3333P = 0 \ \textbf{\textit{(Check!)}}$$

***6-28.** If the maximum force that any member can support is 4 kN in tension and 3 kN in compression, determine the maximum force P that can be supported at point B. Take $d = 1\text{m}$.



Support Reactions :

$$\circlearrowleft + \Sigma M_E = 0; \quad P(2d) - A_y\left(\frac{3}{2}d\right) = 0 \quad A_y = \frac{4}{3}P$$

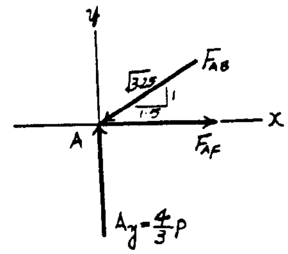
$$+\uparrow \Sigma F_y = 0; \quad \frac{4}{3}P - E_y = 0 \quad E_y = \frac{4}{3}P$$

$$\xrightarrow{+} \Sigma F_x = 0 \quad E_x - P = 0 \quad E_x = P$$

Method of Joints : By inspection of joint C, members CB and CD are zero force member. Hence

$$F_{CB} = F_{CD} = 0$$

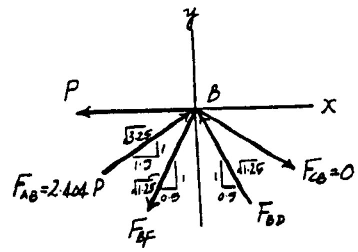
Joint *A*



$$+\uparrow \Sigma F_y = 0; \quad F_{AB}\left(\frac{1}{\sqrt{3.25}}\right) - \frac{4}{3}P = 0 \quad F_{AB} = 2.404P \text{ (C)}$$

$$\xrightarrow{+} \Sigma F_x = 0; \quad F_{AF} - 2.404P\left(\frac{1.5}{\sqrt{3.25}}\right) = 0 \quad F_{AF} = 2.00P \text{ (T)}$$

Joint *B*



$$\xrightarrow{+} \Sigma F_x = 0; \quad 2.404P\left(\frac{1.5}{\sqrt{3.25}}\right) - P - F_{BF}\left(\frac{0.5}{\sqrt{1.25}}\right) - F_{BD}\left(\frac{0.5}{\sqrt{1.25}}\right) = 0$$

$$1.00P - 0.4472F_{BF} - 0.4472F_{BD} = 0 \qquad [1]$$

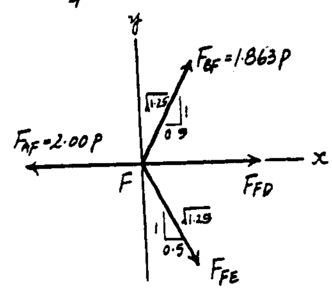
$$+\uparrow \Sigma F_y = 0; \quad 2.404P\left(\frac{1}{\sqrt{3.25}}\right) + F_{BD}\left(\frac{1}{\sqrt{1.25}}\right) - F_{BF}\left(\frac{1}{\sqrt{1.25}}\right) = 0$$

$$1.333P + 0.8944F_{BD} - 0.8944F_{BF} = 0 \qquad [2]$$

Solving Eqs. [1] and [2] yield,

$$F_{BF} = 1.863P\text{(T)} \qquad F_{BD} = 0.3727P\text{(C)}$$

Joint *F*



$$+\uparrow \Sigma F_y = 0; \quad 1.863P\left(\frac{1}{\sqrt{1.25}}\right) - F_{FE}\left(\frac{1}{\sqrt{1.25}}\right) = 0$$

$$F_{FE} = 1.863P\text{(T)}$$

$$\xrightarrow{+} \Sigma F_x = 0; \quad F_{FD} + 2\left[1.863P\left(\frac{0.5}{\sqrt{1.25}}\right)\right] - 2.00P = 0$$

$$F_{FD} = 0.3333P\text{(T)}$$

Joint *D*

$$+\uparrow \Sigma F_y = 0; \quad F_{DE}\left(\frac{1}{\sqrt{1.25}}\right) - 0.3727P\left(\frac{1}{\sqrt{1.25}}\right) = 0$$

$$F_{DE} = 0.3727P \text{ (C)}$$

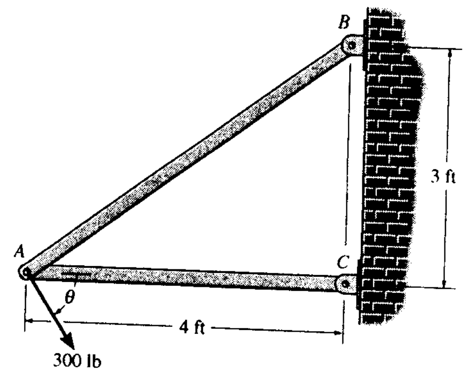
$$\xrightarrow{+} \Sigma F_y = 0; \quad 2\left[0.3727P\left(\frac{0.5}{\sqrt{1.25}}\right)\right] - 0.3333P = 0 \text{ (\textit{Check!})}$$

From the above analysis, the maximum compression and tension in the truss members are $2.404P$ and $2.00P$, respectively. For this case, compression controls which requires

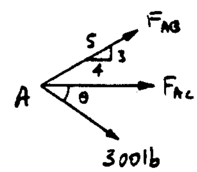
$$2.404P = 3$$

$$P = 1.25 \text{ kN}$$

***6-29.** The two-member truss is subjected to the force of 300 lb. Determine the range of θ for application of the load so that the force in either member does not exceed 400 lb (T) or 200 lb (C).



Joint A :



$$\xrightarrow{+} \Sigma F_x = 0; \quad 300\cos\theta + F_{AC} + F_{AB}\left(\frac{4}{5}\right) = 0$$

$$+\uparrow \Sigma F_y = 0; \quad -300\sin\theta + F_{AB}\left(\frac{3}{5}\right) = 0$$

Thus,

$$F_{AB} = 500\sin\theta$$

$$F_{AC} = -300\cos\theta - 400\sin\theta$$

For AB require :

$$-200 \le 500\sin\theta \le 400$$

$$-2 \le 5\sin\theta \le 4 \qquad (1)$$

For AC require :

$$-200 \le -300\cos\theta - 400\sin\theta \le 400$$

$$-4 \le 3\cos\theta + 4\sin\theta \le 2 \qquad (2)$$

Solving Eqs. (1) and (2) simultaneously,

$127° \le \theta \le 196°$ **Ans**

$336° \le \theta \le 347°$ **Ans**

A possible hand solution :

$$\theta_2 = \theta_1 + \tan^{-1}\left(\frac{3}{4}\right) = \theta_1 + 36.870$$

Then

$$F_{AB} = 500\sin\theta_1$$

$$F_{AC} = -300\cos(\theta_2 - 36.870°) - 400\sin(\theta_2 - 36.870°)$$

$$= -300\,[\cos\theta_2\cos 36.870° + \sin\theta_2\sin 36.870°]$$

$$-400\,[\sin\theta_2\cos 36.870° - \cos\theta_2\sin 36.870°]$$

$$= -240\cos\theta_2 - 180\sin\theta_2 - 320\sin\theta_2 + 240\cos\theta_2$$

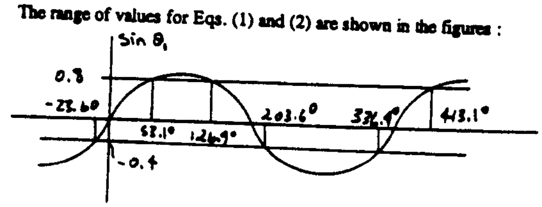
$$= -500\sin\theta_2$$

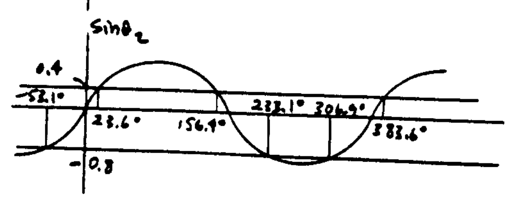
Thus, we require

$$-2 \le 5\sin\theta_1 \le 4 \quad \text{or} \quad -0.4 \le \sin\theta_1 \le 0.8 \qquad (1)$$

$$-4 \le 5\sin\theta_2 \le 2 \quad \text{or} \quad -0.8 \le \sin\theta_2 \le 0.4 \qquad (2)$$

The range of values for Eqs. (1) and (2) are shown in the figures :



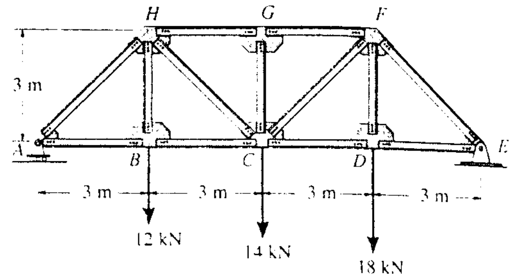


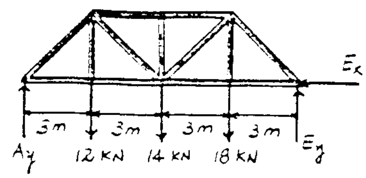
Since $\theta_1 = \theta_2 - 36.870°$, the range of acceptable values for $\theta = \theta_1$ is

$127° \le \theta \le 196°$ **Ans**

$336° \le \theta \le 347°$ **Ans**

6-30. Determine the force in members BC, HC, and HG of the bridge truss, and indicate whether the members are in tension or compression.





Support Reactions :

$\circlearrowleft + \Sigma M_E = 0;\quad 18(3) + 14(6) + 12(9) - A_y(12) = 0 \qquad A_y = 20.5 \text{ kN}$

Method of Sections :

$\circlearrowleft + \Sigma M_C = 0;\quad F_{HG}(3) + 12(3) - 20.5(6) = 0$

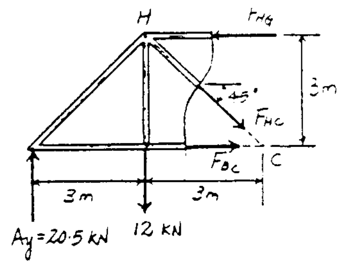
$F_{HG} = 29.0 \text{ kN (C)}$ **Ans**

$\circlearrowleft + \Sigma M_H = 0;\quad F_{BC}(3) - 20.5(3) = 0$

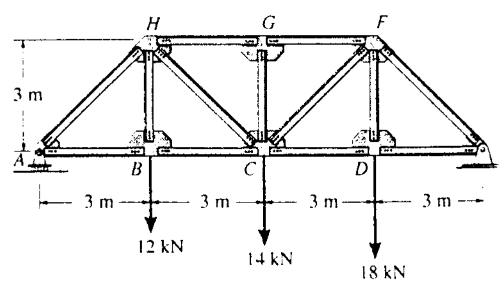
$F_{BC} = 20.5 \text{ kN (T)}$ **Ans**

$+\uparrow \Sigma F_y = 0;\quad 20.5 - 12 - F_{HC}\sin 45° = 0$

$F_{HC} = 12.0 \text{ kN (T)}$ **Ans**



6-31. Determine the force in members GF, CF, and CD of the bridge truss, and indicate whether the members are in tension or compression.



Support Reactions :

$\circlearrowleft + \Sigma M_A = 0;\quad E_y(12) - 18(9) - 14(6) - 12(3) = 0 \qquad E_y = 23.5 \text{ kN}$

$\xrightarrow{+} \Sigma F_x = 0;\qquad E_x = 0$

Method of Sections :

$\circlearrowleft + \Sigma M_C = 0;\quad 23.5(6) - 18(3) - F_{GF}(3) = 0$

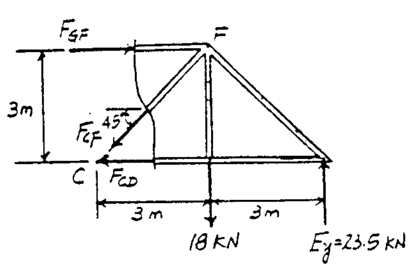
$F_{GF} = 29.0 \text{ kN (C)}$ **Ans**

$\circlearrowleft + \Sigma M_F = 0;\quad 23.5(3) - F_{CD}(3) = 0$

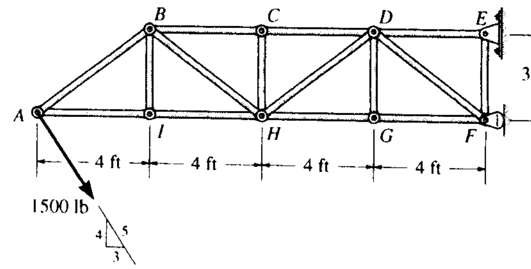
$F_{CD} = 23.5 \text{ kN (T)}$ **Ans**

$+\uparrow \Sigma F_y = 0;\quad 23.5 - 18 - F_{CF}\sin 45° = 0$

$F_{CF} = 7.78 \text{ kN (T)}$ **Ans**



*6-32. Determine the force in members DE, DF, and GF of the cantilevered truss and state if the members are in tension or compression.



$+\uparrow \Sigma F_y = 0; \quad \frac{3}{5}F_{DF} - \frac{4}{5}(1500) = 0$

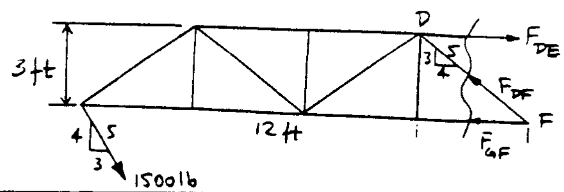
$F_{DF} = 2000 \text{ lb} = 2.0 \text{ kip (C)}$ **Ans**

$\circlearrowleft + \Sigma M_D = 0; \quad \frac{4}{5}(1500)(12) + \frac{3}{5}(1500)(3) - F_{GF}(3) = 0$

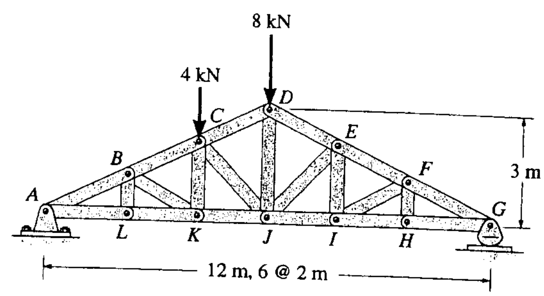
$F_{GF} = 5700 \text{ lb} = 5.70 \text{ kip (C)}$ **Ans**

$\circlearrowleft + \Sigma M_F = 0; \quad \frac{4}{5}(1500)(16) - F_{DE}(3) = 0$

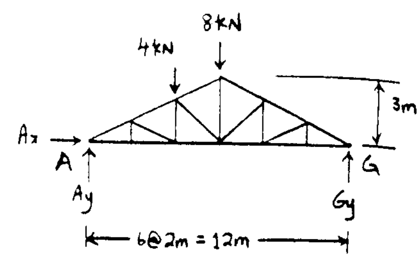
$F_{DE} = 6400 \text{ lb} = 6.40 \text{ kip (T)}$ **Ans**



6-33. The roof truss supports the vertical loading shown. Determine the force in members BC, CK, and KJ and state if these members are in tension or compression.



$\xrightarrow{+} \Sigma F_x = 0; \quad A_x = 0$



$\circlearrowleft + \Sigma M_G = 0; \quad -A_y(12) + 4(8) + 8(6) = 0$

$A_y = 6.667 \text{ kN}$

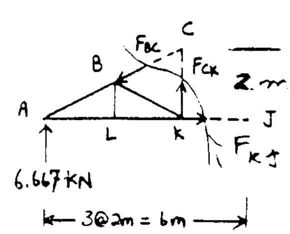
$\circlearrowleft + \Sigma M_C = 0; \quad -6.667(4) + F_{KJ}(2) = 0$

$F_{KJ} = 13.3 \text{ kN (T)}$ **Ans**

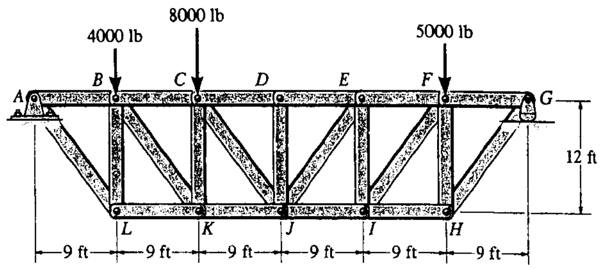
$\circlearrowleft + \Sigma M_K = 0; \quad 6.667(4) - \frac{2}{\sqrt{5}}F_{BC}(2) = 0$

$F_{BC} = 14.907 = 14.9 \text{ kN (C)}$ **Ans**

$\circlearrowleft + \Sigma M_A = 0; \quad F_{CK} = 0$ **Ans**



6-34. Determine the force in members *CD*, *CJ*, *KJ*, and *DJ* of the truss which serves to support the deck of a bridge. State if these members are in tension or compression.



$\circlearrowleft + \Sigma M_C = 0;$ $\quad -9500(18) + 4000(9) + F_{KJ}(12) = 0$

$F_{KJ} = 11\,250 \text{ lb} = 11.2 \text{ kip (T)}$ **Ans**

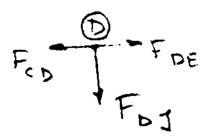
$\circlearrowleft + \Sigma M_J = 0;$ $\quad -9500(27) + 4000(18) + 8000(9) + F_{CD}(12) = 0$

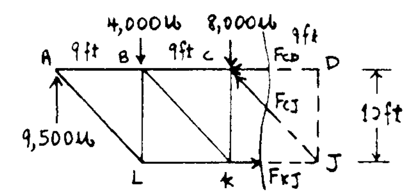
$F_{CD} = 9375 \text{ lb} = 9.38 \text{ kip (C)}$ **Ans**

$\xrightarrow{+} \Sigma F_x = 0;$ $\quad -9375 + 11\,250 - \frac{3}{5}F_{CJ} = 0$

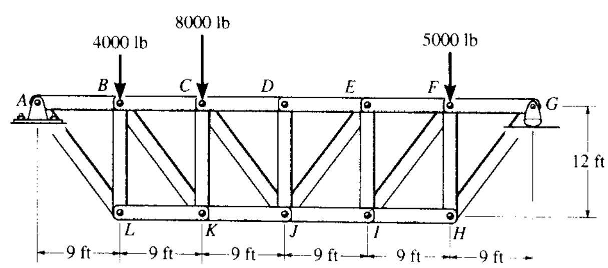
$F_{CJ} = 3125 \text{ lb} = 3.12 \text{ kip (C)}$ **Ans**

Joint *D*, $\quad F_{DJ} = 0$ **Ans**





6-35. Determine the force in members *EI* and *JI* of the truss which serves to support the deck of a bridge. State if these members are in tension or compression.

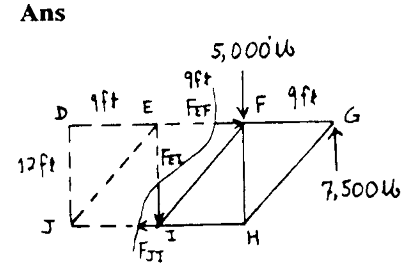


$\circlearrowleft + \Sigma M_E = 0;$ $\quad -5000(9) + 7500(18) - F_{JI}(12) = 0$

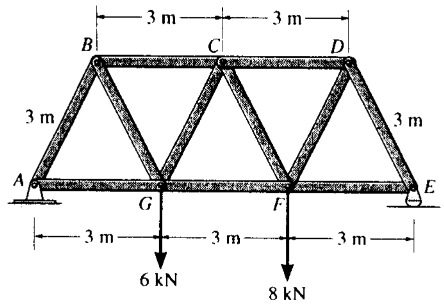
$F_{JI} = 7500 \text{ lb} = 7.50 \text{ kip (T)}$ **Ans**

$+\uparrow \Sigma F_y = 0;$ $\quad 7500 - 5000 - F_{EI} = 0$

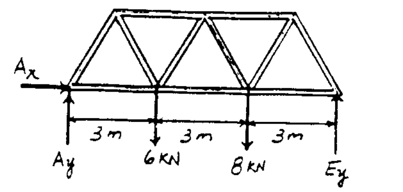
$F_{EI} = 2500 \text{ lb} = 2.50 \text{ kip (C)}$ **Ans**



***6-36.** Determine the force in members *BC*, *CG*, and *GF* of the *Warren truss*. Indicate if the members are in tension or compression.



Support Reactions :



$\curvearrowleft + \Sigma M_E = 0; \quad 6(6) + 8(3) - A_y(9) = 0 \qquad A_y = 6.667 \text{ kN}$

$\xrightarrow{+} \Sigma F_x = 0; \qquad A_x = 0$

Method of Sections :

$\curvearrowleft + \Sigma M_C = 0; \quad F_{GF}(3\sin 60°) + 6(1.5) - 6.667(4.5) = 0$

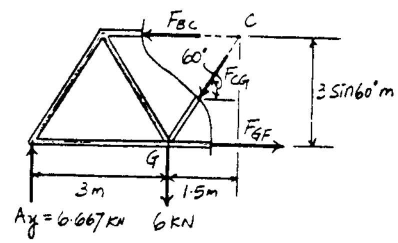
$F_{GF} = 8.08 \text{ kN (T)}$ **Ans**

$\curvearrowleft + \Sigma M_G = 0; \quad F_{BC}(3\sin 60°) - 6.667(3) = 0$

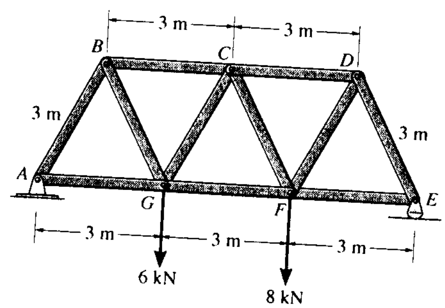
$F_{BC} = 7.70 \text{ kN (C)}$ **Ans**

$+\uparrow \Sigma F_y = 0; \quad 6.667 - 6 - F_{CG}\sin 60° = 0$

$F_{CG} = 0.770 \text{ kN (C)}$ **Ans**



6-37. Determine the force in members *CD*, *CF*, and *FG* of the *Warren truss*. Indicate if the members are in tension or compression.



Support Reactions :

$\curvearrowleft + \Sigma M_A = 0; \quad E_y(9) - 8(6) - 6(3) = 0 \qquad E_y = 7.333 \text{ kN}$

Method of Sections :

$\curvearrowleft + \Sigma M_C = 0; \quad 7.333(4.5) - 8(1.5) - F_{FG}(3\sin 60°) = 0$

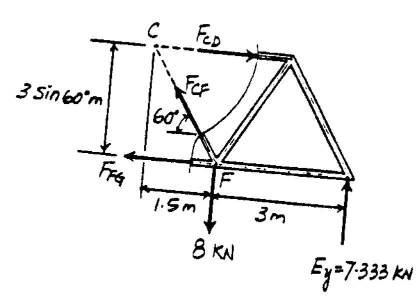
$F_{FG} = 8.08 \text{ kN (T)}$ **Ans**

$\curvearrowleft + \Sigma M_F = 0; \quad 7.333(3) - F_{CD}(3\sin 60°) = 0$

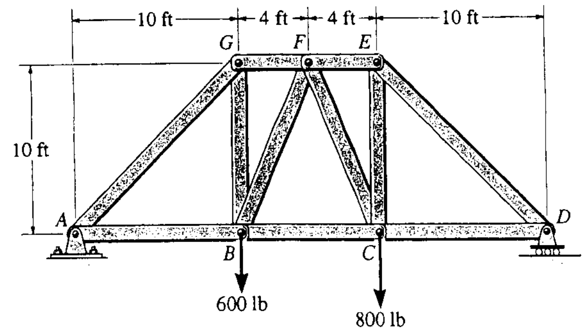
$F_{CD} = 8.47 \text{ kN (C)}$ **Ans**

$+\uparrow \Sigma F_y = 0; \quad F_{CF}\sin 60° + 7.333 - 8 = 0$

$F_{CF} = 0.770 \text{ kN (T)}$ **Ans**

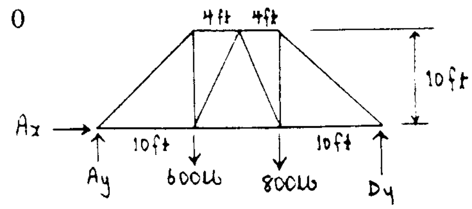


6-38. Determine the force developed in members GB and GF of the bridge truss and state if these members are in tension or compression.



$\curvearrowleft + \Sigma M_A = 0;\quad -600(10) - 800(18) + D_y(28) = 0$

$D_y = 728.571 \text{ lb}$



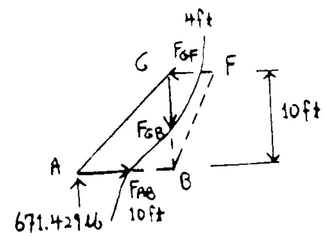
$\xrightarrow{+} \Sigma F_x = 0;\quad A_x = 0$

$+\uparrow \Sigma F_y = 0;\quad A_y - 600 - 800 + 728.571 = 0$

$A_y = 671.429 \text{ lb}$

$\curvearrowleft + \Sigma M_B = 0;\quad -671.429(10) + F_{GF}(10) = 0$

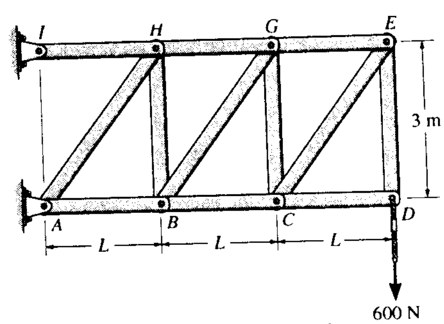
$F_{GF} = 671.429 \text{ lb} = 671 \text{ lb (C)}$ **Ans**



$+\uparrow \Sigma F_y = 0;\quad 671.429 - F_{GB} = 0$

$F_{GB} = 671 \text{ lb (T)}$ **Ans**

•6-39. The truss supports the vertical load of 600 N. Determine the force in members BC, BG, and HG as the dimension L varies. Plot the results of F (ordinate with tension as positive) versus L (abscissa) for $0 \le L \le 3$ m.



$+\uparrow \Sigma F_y = 0;\quad -600 - F_{BG}\sin\theta = 0$

$F_{BG} = -\dfrac{600}{\sin\theta}$

$\sin\theta = \dfrac{3}{\sqrt{L^2+9}}$

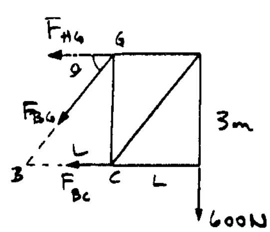
$F_{BG} = -200\sqrt{L^2+9}$

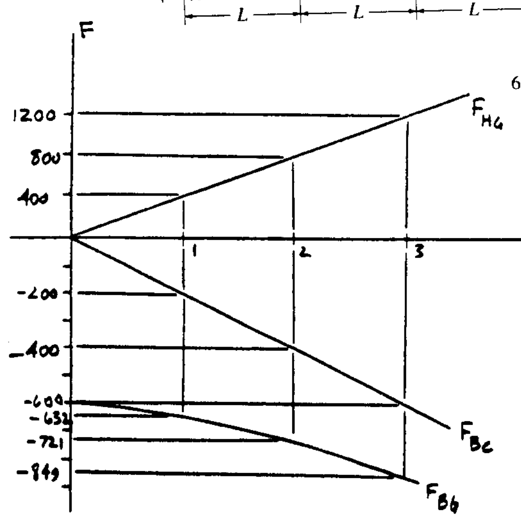
$\curvearrowleft + \Sigma M_G = 0;\quad -F_{BC}(3) - 600(L) = 0$

$F_{BC} = -200L$

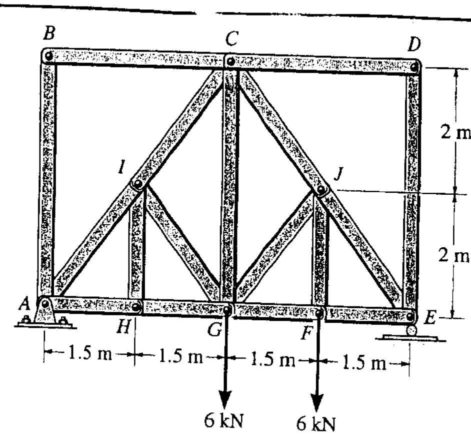
$\curvearrowleft + \Sigma M_B = 0;\quad F_{HG}(3) - 600(2L) = 0$

$F_{HG} = 400L$





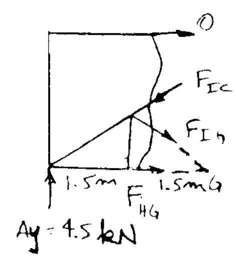
***6-40.** Determine the force in members IC and CG of the truss and state if these members are in tension or compression. Also, indicate all zero-force members.



By inspection of joints B, D, H and I,

AB, BC, CD, DE, HI, and GI are all zero-force members. **Ans**

$$\circlearrowleft + \Sigma M_G = 0; \qquad -4.5(3) + F_{IC}\left(\frac{3}{5}\right)(4) = 0$$

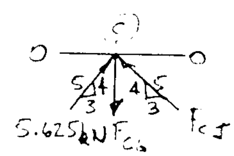


$$F_{IC} = 5.62 \text{ kN (C)}$$ **Ans**

Joint C:

$$\xrightarrow{+} \Sigma F_x = 0; \qquad F_{CJ} = 5.625 \text{ kN}$$

$$+\uparrow \Sigma F_y = 0; \qquad \frac{4}{5}(5.625) + \frac{4}{5}(5.625) - F_{CG} = 0$$



$$F_{CG} = 9.00 \text{ kN (T)}$$ **Ans**

6-41. Determine the force in members JE and GF of the truss and state if these members are in tension or compression. Also, indicate all zero-force members.

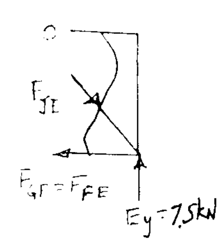
By inspection of joints B, D, H and I,

AB, BC, CD, DE, HI, and GI are zero-force members. **Ans**

Joint E:

$$+\uparrow \Sigma F_y = 0; \qquad 7.5 - \frac{4}{5}F_{JE} = 0$$

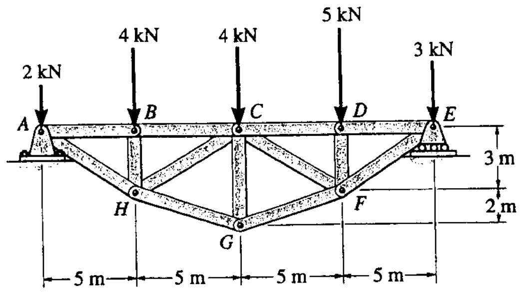
$$F_{JE} = 9.375 = 9.38 \text{ kN (C)}$$ **Ans**



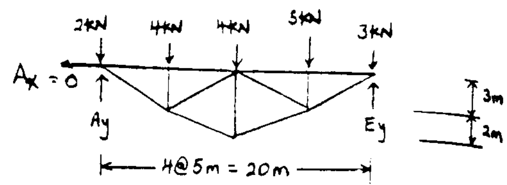
$$\xrightarrow{+} \Sigma F_x = 0; \qquad \frac{3}{5}(9.375) - F_{GF} = 0$$

$$F_{GF} = 5.625 \text{ kN (T)}$$ **Ans**

6-42. Determine the force in members BC, HC, and HG. After the truss is sectioned use a single equation of equilibrium for the calculation of each force. State if these members are in tension or compression.



Probs. 6–42/43

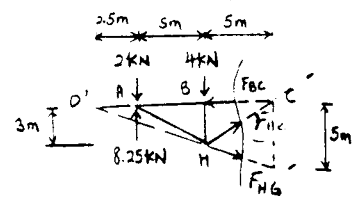


$\curvearrowleft + \Sigma M_E = 0;$ $\quad -A_y(20) + 2(20) + 4(15) + 4(10) + 5(5) = 0$

$A_y = 8.25 \text{ kN}$

$\curvearrowleft + \Sigma M_H = 0;$ $\quad -8.25(5) + 2(5) + F_{BC}(3) = 0$

$F_{BC} = 10.4 \text{ kN (C)}$ **Ans**



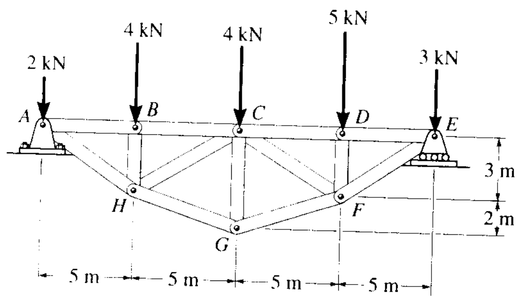
$\curvearrowleft + \Sigma M_C = 0;$ $\quad -8.25(10) + 2(10) + 4(5) + \frac{5}{\sqrt{29}} F_{HG}(5) = 0$

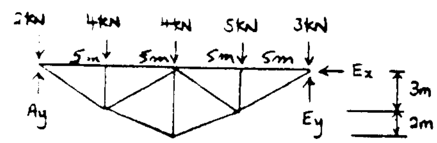
$F_{HG} = 9.155 = 9.16 \text{ kN (T)}$ **Ans**

$\curvearrowleft + \Sigma M_{O'} = 0;$ $\quad -2(2.5) + 8.25(2.5) - 4(7.5) + \frac{3}{\sqrt{34}} F_{HC}(12.5) = 0$

$F_{HC} = 2.24 \text{ kN (T)}$ **Ans**

6-43. Determine the force in members *CD, CF,* and *CG* and state if these members are in tension or compression.

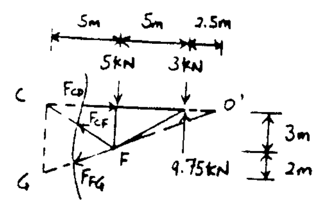




$\xrightarrow{+}\Sigma F_x = 0;$ $\quad E_x = 0$

$\circlearrowleft + \Sigma M_A = 0;$ $\quad -4(5) - 4(10) - 5(15) - 3(20) + E_y(20) = 0$

$E_y = 9.75 \text{ kN}$



$\circlearrowleft + \Sigma M_C = 0;$ $\quad -5(5) - 3(10) + 9.75(10) - \frac{5}{\sqrt{29}}F_{FG}(5) = 0$

$F_{FG} = 9.155 \text{ kN (T)}$

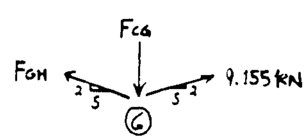
$\circlearrowleft + \Sigma M_F = 0;$ $\quad -3(5) + 9.75(5) - F_{CD}(3) = 0$

$F_{CD} = 11.25 = 11.2 \text{ kN (C)}$ **Ans**

$\circlearrowleft + \Sigma M_{O'} = 0;$ $\quad -9.75(2.5) + 5(7.5) + 3(2.5) - \frac{3}{\sqrt{34}}F_{CF}(12.5) = 0$

$F_{CF} = 3.21 \text{ kN (T)}$ **Ans**

Joint *G* :

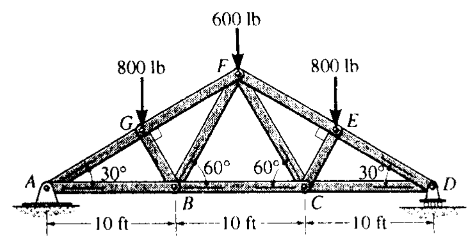


$\xrightarrow{+}\Sigma F_x = 0;$ $\quad F_{GH} = 9.155 \text{ kN (T)}$

$+\uparrow \Sigma F_y = 0;$ $\quad \frac{2}{\sqrt{29}}(9.155)(2) - F_{CG} = 0$

$F_{CG} = 6.80 \text{ kN (C)}$ **Ans**

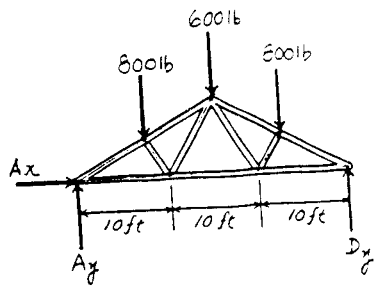
***6-44.** Determine the force in members *GF*, *FB*, and *BC* of the *Fink truss* and state if the members are in tension or compression.



Support Reactions : Due to symmetry, $D_y = A_y$.

$+\uparrow \Sigma F_y = 0; \quad 2A_y - 800 - 600 - 800 = 0 \quad A_y = 1100 \text{ lb}$

$\xrightarrow{+} \Sigma F_x = 0; \quad A_x = 0$



Method of Sections :

$\curvearrowleft + \Sigma M_B = 0; \quad F_{GF}\sin 30°(10) + 800(10 - 10\cos^2 30°) - 1100(10) = 0$

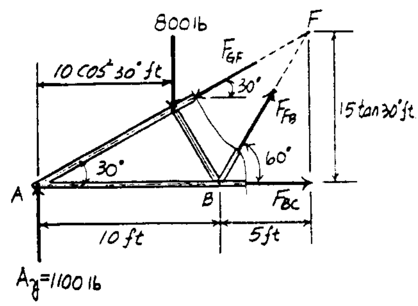
$F_{GF} = 1800 \text{ lb (C)} = 1.80 \text{ kip (C)}$ **Ans**

$\curvearrowleft + \Sigma M_A = 0; \quad F_{FB}\sin 60°(10) - 800(10\cos^2 30°) = 0$

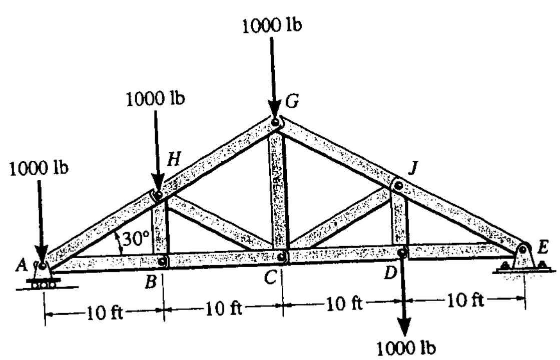
$F_{FB} = 692.82 \text{ lb (T)} = 693 \text{ lb (T)}$ **Ans**

$\curvearrowleft + \Sigma M_F = 0; \quad F_{BC}(15\tan 30°) + 800(15 - 10\cos^2 30°) - 1100(15) = 0$

$F_{BC} = 1212.43 \text{ lb (T)} = 1.21 \text{ kip (T)}$ **Ans**

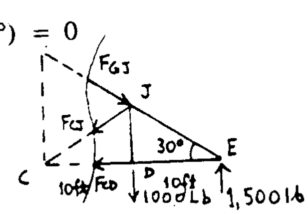


6-45. Determine the force in member *GJ* of the truss and state if this member is in tension or compression.

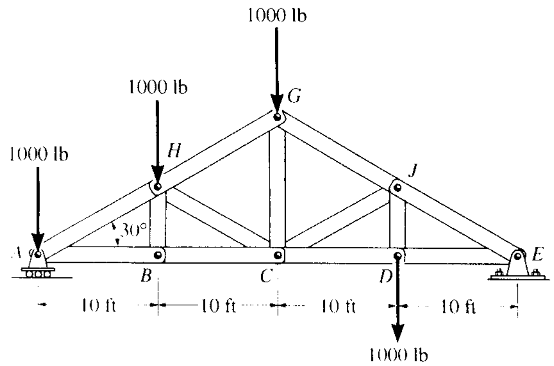


$\curvearrowleft + \Sigma M_C = 0; \quad -1000(10) + 1500(20) - F_{GJ}\cos 30°(20\tan 30°) = 0$

$F_{GJ} = 2.00 \text{ kip (C)}$ **Ans**



6-46. Determine the force in member GC of the truss and state if this member is in tension or compression.



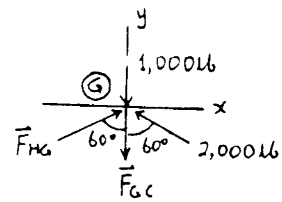
Using the results of Prob. 6 – 45 :

Joint G :

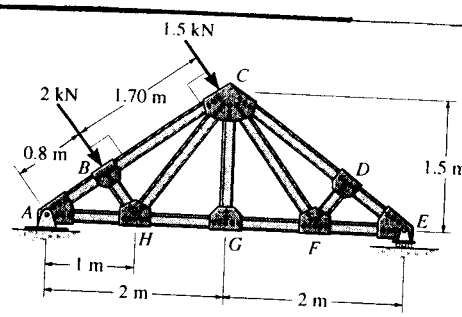
$\xrightarrow{+}\Sigma F_x = 0;$ $\quad F_{HG} = 2000$ lb

$+\uparrow \Sigma F_y = 0;$ $\quad -1000 + 2(2000\cos 60°) - F_{GC} = 0$

$F_{GC} = 1.00$ kip (T) **Ans**



6-47. Determine the force in members GF, CF, and CD of the roof truss and indicate if the members are in tension or compression.



$\circlearrowleft + \Sigma M_A = 0;$ $\quad E_y(4) - 2(0.8) - 1.5(2.50) = 0 \quad E_y = 1.3375$ kN

Method of Sections :

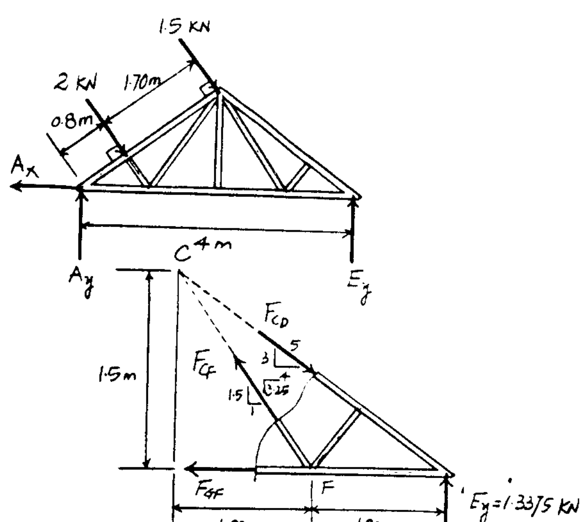
$\circlearrowleft + \Sigma M_C = 0;$ $\quad 1.3375(2) - F_{GF}(1.5) = 0$

$F_{GF} = 1.78$ kN (T) **Ans**

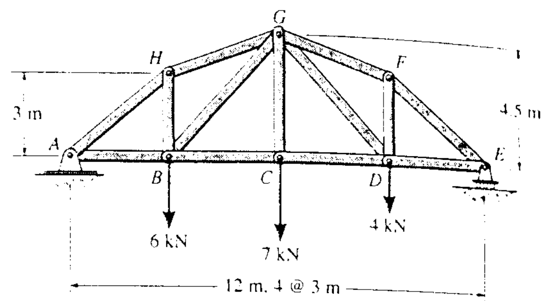
$\circlearrowleft + \Sigma M_F = 0;$ $\quad 1.3375(1) - F_{CD}\left(\frac{3}{5}\right)(1) = 0$

$F_{CD} = 2.23$ kN (C) **Ans**

$\circlearrowleft + \Sigma M_E = 0;$ $\quad F_{CF}\left(\frac{1.5}{\sqrt{3.25}}\right)(1) = 0 \quad F_{CF} = 0$ **Ans**

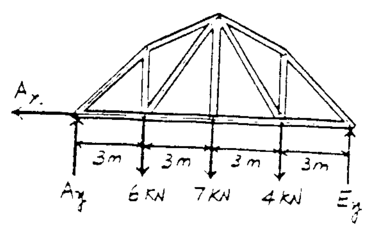


***6-48.** Determine the force in members BG, HG, and BC of the truss and state if the members are in tension or compression.



$\circlearrowleft + \Sigma M_E = 0; \quad 6(9) + 7(6) + 4(3) - A_y(12) = 0 \quad A_y = 9.00 \text{ kN}$

$\xrightarrow{+} \Sigma F_x = 0; \quad A_x = 0$



Method of Sections :

$\circlearrowleft + \Sigma M_G = 0; \quad F_{BC}(4.5) + 6(3) - 9(6) = 0$

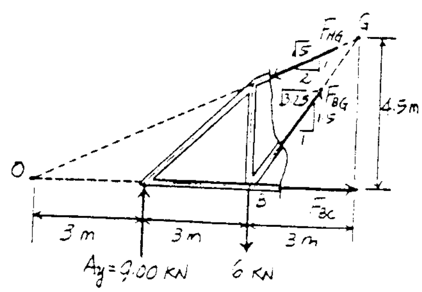
$F_{BC} = 8.00 \text{ kN (T)}$ **Ans**

$\circlearrowleft + \Sigma M_B = 0; \quad F_{HG}\left(\frac{1}{\sqrt{5}}\right)(6) - 9(3) = 0$

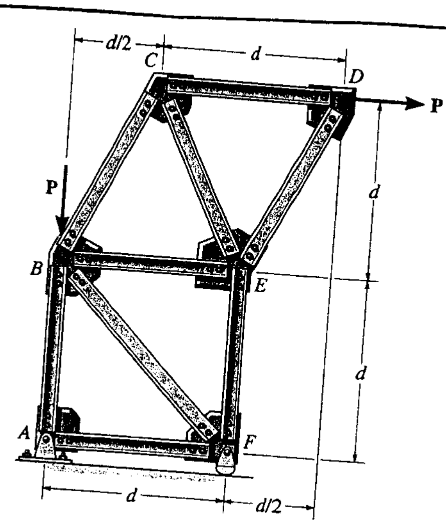
$F_{HG} = 10.1 \text{ kN (C)}$ **Ans**

$\circlearrowleft + \Sigma M_O = 0; \quad F_{BG}\left(\frac{1.5}{\sqrt{3.25}}\right)(6) + 9(3) - 6(6) = 0$

$F_{BG} = 1.80 \text{ kN (T)}$ **Ans**

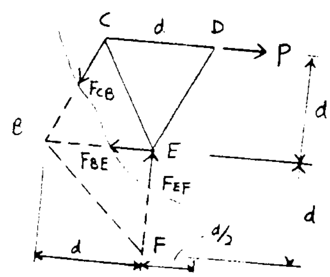


6-49. The skewed truss carries the load shown. Determine the force in members *CB*, *BE*, and *EF* and state if these members are in tension or compression. Assume that all joints are pinned.



$\circlearrowleft + \Sigma M_B = 0; \qquad -P(d) + F_{EF}(d) = 0$

$F_{EF} = P \text{ (C)}$ **Ans**



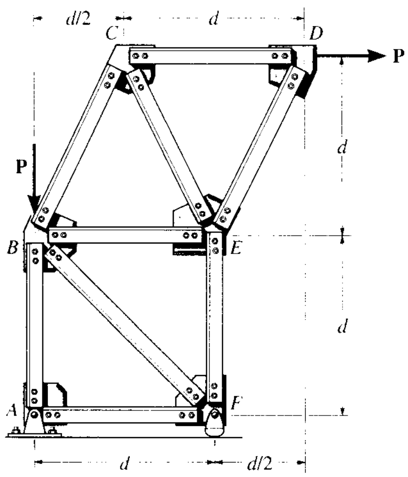
$\circlearrowleft + \Sigma M_E = 0; \qquad -P(d) + \left[\dfrac{d}{\sqrt{(d)^2 + (\frac{d}{2})^2}}\right] F_{CB}(d) = 0$

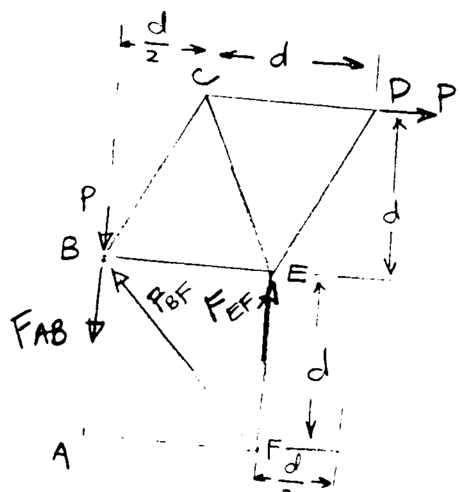
$F_{CB} = 1.12P \text{ (T)}$ **Ans**

$\overset{+}{\rightarrow} \Sigma F_x = 0; \qquad P - \dfrac{0.5}{\sqrt{1.25}}(1.12P) - F_{BE} = 0$

$F_{BE} = 0.5P \text{ (T)}$ **Ans**

6-50. The skewed truss carries the load shown. Determine the force in members AB, BF, and EF and state if these members are in tension or compression. Assume that all joints are pinned.





$\circlearrowleft + \Sigma M_F = 0; \qquad -P(2d) + P(d) + F_{AB}(d) = 0$

$F_{AB} = P \text{ (T)}$ **Ans**

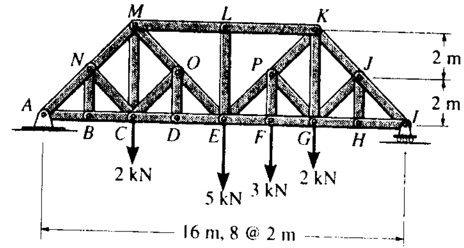
$\circlearrowleft + \Sigma M_B = 0; \qquad -P(d) + F_{EF}(d) = 0$

$F_{EF} = P \text{ (C)}$ **Ans**

$\overset{+}{\rightarrow} \Sigma F_x = 0; \qquad P - F_{BF}\left(\frac{1}{\sqrt{2}}\right) = 0$

$F_{BF} = 1.41P \text{ (C)}$ **Ans**

*6-51. Determine the force in members CD and CM of the *Baltimore bridge truss* and state if the members are in tension or compression. Also, indicate all zero-force members.



Support Reactions :

$$\curvearrowleft + \Sigma M_I = 0; \quad 2(12) + 5(8) + 3(6) + 2(4) - A_y(16) = 0$$
$$A_y = 5.625 \text{ kN}$$

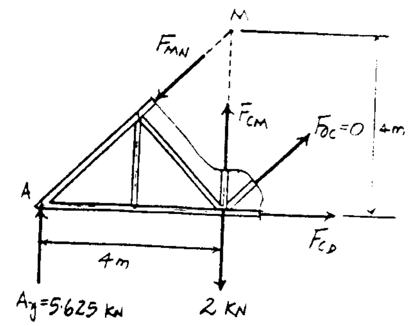
$$\xrightarrow{+} \Sigma F_x = 0; \quad A_x = 0$$

Method of Joints : By inspection, members ***BN, NC, DO, OC, HJ LE*** and ***JG*** are zero force member. **Ans**

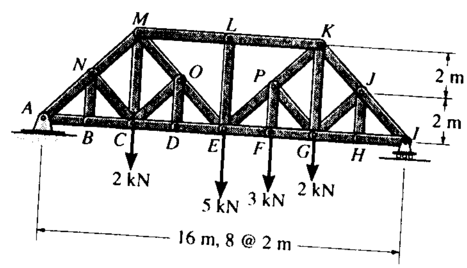
Method of Sections :

$$\curvearrowleft + \Sigma M_M = 0; \quad F_{CD}(4) - 5.625(4) = 0$$
$$F_{CD} = 5.625 \text{ kN (T)} \quad \textbf{Ans}$$

$$\curvearrowleft + \Sigma M_A = 0; \quad F_{CM}(4) - 2(4) = 0$$
$$F_{CM} = 2.00 \text{ kN (T)} \quad \textbf{Ans}$$



*6-52. Determine the force in members EF, EP, and LK of the *Baltimore bridge truss* and state if the members are in tension or compression. Also, indicate all zero-force members.



Support Reactions :

$$\curvearrowleft + \Sigma M_A = 0; \quad I_y(16) - 2(12) - 3(10) - 5(8) - 2(4) = 0$$
$$I_y = 6.375 \text{ kN}$$

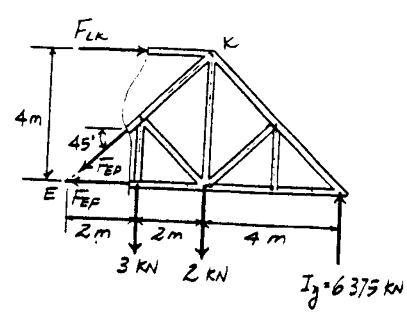
Method of Joints : By inspection, members ***BN, NC, DO, OC, HJ LE*** and ***JG*** are zero force member. **Ans**

Method of Sections :

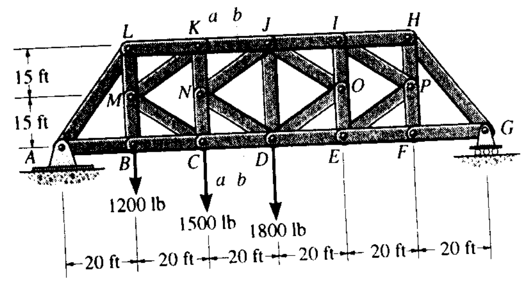
$$\curvearrowleft + \Sigma M_K = 0; \quad 3(2) + 6.375(4) - F_{EF}(4) = 0$$
$$F_{EF} = 7.875 \text{ kN (T)} \quad \textbf{Ans}$$

$$\curvearrowleft + \Sigma M_E = 0; \quad 6.375(8) - 2(4) - 3(2) - F_{LK}(4) = 0$$
$$F_{LK} = 9.25 \text{ kN (C)} \quad \textbf{Ans}$$

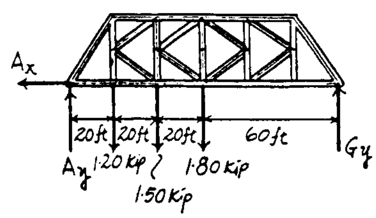
$$+\uparrow \Sigma F_y = 0; \quad 6.375 - 3 - 2 - F_{ED}\sin 45° = 0$$
$$F_{EP} = 1.94 \text{ kN (T)} \quad \textbf{Ans}$$



6-53. Determine the force in members *KJ*, *NJ*, *ND*, and *CD* of the *K truss*. Indicate if the members are in tension or compression. *Hint:* Use sections *aa* and *bb*.



Support Reactions :

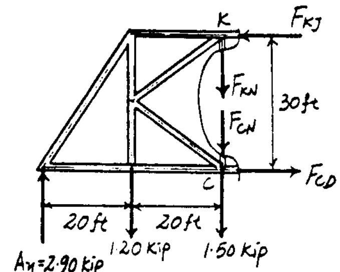


$\curvearrowleft + \Sigma M_G = 0;\quad 1.20(100) + 1.50(80) + 1.80(60) - A_y(120) = 0$

$A_y = 2.90$ kip

$\xrightarrow{+} \Sigma F_x = 0;\quad A_x = 0$

Method of Sections : From section $a-a$, F_{KJ} and F_{CD} can be obtained directly by summing moment about points C and K respectively.



$\curvearrowleft + \Sigma M_C = 0;\quad F_{KJ}(30) + 1.20(20) - 2.90(40) = 0$

$F_{KJ} = 3.067 \text{ kip (C)} = 3.07 \text{ kip (C)}$ **Ans**

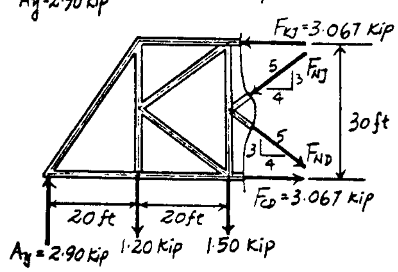
$\curvearrowleft + \Sigma M_K = 0;\quad F_{CD}(30) + 1.20(20) - 2.90(40) = 0$

$F_{CD} = 3.067 \text{ kip (T)} = 3.07 \text{ kip (T)}$ **Ans**

From sec $b-b$, summing forces along x and y axes yields

$\xrightarrow{+} \Sigma F_x = 0;\quad F_{ND}\left(\frac{4}{5}\right) - F_{NJ}\left(\frac{4}{5}\right) + 3.067 - 3.067 = 0$

$F_{ND} = F_{NJ}$ [1]



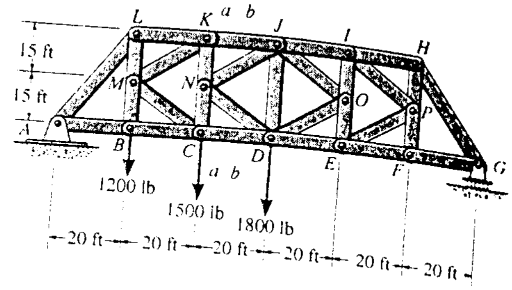
$+\uparrow \Sigma F_y = 0;\quad 2.90 - 1.20 - 1.50 - F_{ND}\left(\frac{3}{5}\right) - F_{NJ}\left(\frac{3}{5}\right) = 0$

$F_{ND} + F_{NJ} = 0.3333$ [2]

Solving Eqs. [1] and [2] yields

$F_{ND} = 0.167 \text{ kip (T)}\quad F_{NJ} = 0.167 \text{ kip (C)}$ **Ans**

6-54. Determine the force in members JI and DE of the K *truss*. Indicate if the members are in tension or compression.

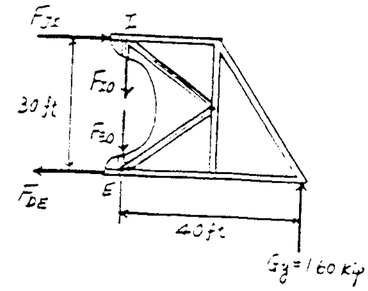


Support Reactions :

$\curvearrowleft + \Sigma M_A = 0;\quad G_y(120) - 1.80(60) - 1.50(40) - 1.20(20) = 0$

$G_y = 1.60$ kip

Method of Sections :



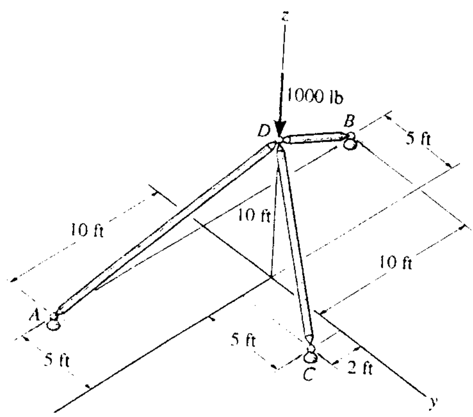
$\curvearrowleft + \Sigma M_E = 0;\quad 1.60(40) - F_{JI}(30) = 0$

$F_{JI} = 2.13$ kip (C) **Ans**

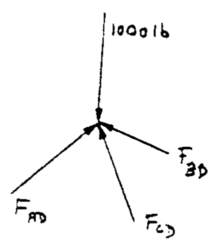
$\curvearrowleft + \Sigma M_I = 0;\quad 1.60(40) - F_{DE}(30) = 0$

$F_{DE} = 2.13$ kip (T) **Ans**

6-55. Determine the force in each member of the three-member space truss that supports the loading of 1000 lb and state if the members are in tension or compression.



Joint D :



$$\mathbf{F}_{AD} = F_{AD}\left(-\frac{10}{15}\mathbf{i} + \frac{5}{15}\mathbf{j} + \frac{10}{15}\mathbf{k}\right)$$

$$\mathbf{F}_{CD} = F_{CD}\left(-\frac{2}{11.358}\mathbf{i} - \frac{5}{11.358}\mathbf{j} + \frac{10}{11.358}\mathbf{k}\right)$$

$$\mathbf{F}_{BD} = F_{BD}\left(\frac{10}{15}\mathbf{i} + \frac{5}{15}\mathbf{j} + \frac{10}{15}\mathbf{k}\right)$$

$$\mathbf{P} = -1000\,\mathbf{k}$$

$$\Sigma F_x = 0;\quad F_{AD}\left(-\frac{10}{15}\right) + F_{CD}\left(-\frac{2}{11.358}\right) + F_{BD}\left(\frac{10}{15}\right) = 0$$

$$\Sigma F_y = 0;\quad F_{AD}\left(\frac{5}{15}\right) + F_{CD}\left(-\frac{5}{11.358}\right) + F_{BD}\left(\frac{5}{15}\right) = 0$$

$$\Sigma F_z = 0;\quad F_{AD}\left(\frac{10}{15}\right) + F_{CD}\left(\frac{10}{11.358}\right) + F_{BD}\left(\frac{10}{15}\right) - 1000 = 0$$

Solving,

$F_{AD} = 300$ lb (C) **Ans**

$F_{BD} = 450$ lb (C) **Ans**

$F_{CD} = 568$ lb (C) **Ans**